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永續運輸政策認知之實證研究

Empirical Study on Beliefs of Sustainable Transportation Policies

研 究 生：陳賓權

指導教授：張新立 教授

中 華 民 國 一 〇 〇 年 七 月

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In Memory of My Father, and Dedicated to My Dearest Family

永續運輸政策認知之實證研究

學生：陳賓權　　指導教授：張新立 教授

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摘要

本研究主要目的是針對永續運輸政策相關利害關係人（包括資深公務員及一般民眾）的潛在心理構面進行探索，並發展一個概念性架構來衡量其對政策的認知。我們綜合個人對政策信仰的主觀限制與客觀考量，概念化成為一種潛在心理構面，進一步探究政策信仰有助於政策制定之始洞悉利害關係人的偏好，並可事先預測政策執行的效果。本研究首先討論政策信仰的定義及可能影響政策信仰的因素，接著導入一個有效的方法論來衡量資深公務員及一般民眾政策信仰；其次，我們將透過實證研究來取得資深公務員及一般民眾對永續運輸的政策信仰，並比較兩者之間的差異。

本研究使用 Rasch 模式針對資深公務員及一般民眾對永續運輸的政策信仰以數量化的方式進行評估，研究結果發現，不管是資深公務員或一般民眾，都偏好支持不會限制人民偏好或自由的政策，也都認為提供更有效、更友善的公共運輸服務會比透過提高使用成本來限制私人運具使用更能達成永續運輸的目的。分析資深公務員的社經特性則發現，在同一工作職務愈久、累積工作經驗愈多、擁有權力愈大，則愈相信自己本身有能力制定政策、愈能夠判斷政策可行性，在執行政策時也愈有信心。

進一步觀察一般民眾使用通勤工具與永續運輸政策信仰的關係，發現使用公共運輸工具通勤者與一般大眾對永續運輸政策的偏好是相同的，兩者都認為「開發新能源技術」是對永續運輸發展最有幫助的政策；相對地，對使用私人運具通勤以及回答未來有意願減少私人運具使用者，則比一般大眾更相信「興建軌道運輸系統」更能夠達成永續運輸環境的政策目標。

透過 DIF 分析，本研究同時發現使用公共運輸及沒有小汽車的人則分別比使

用私人運具通勤與擁有小汽車者更認同「都會區實施擁擠收費」以及「提高油價或停車費」等經濟管制措施。但相對地，使用私人運具通勤與擁有小汽車者會分別比使用公共運輸及沒有小汽車的人更認同「提供即時資訊」、「補貼改裝 LPG 車」，以及「實施 ETC」等項目是有助於永續運輸。而是否擁有小客車的不同族群透過 DIF 分析也得到前述相同的結果。

此外，本研究透過獨立樣本 t 檢定來檢視資深公務員與一般民眾對政策認知的差異，結果發現兩者對「興建軌道運輸系統」的支持度一致，但對其他政策項目則顯示資深公務員比一般民眾對政策是否有助於永續運輸發展的評估要更為保守，這顯示一般民眾比較樂觀看待永續運輸政策的推動，也比參與政策制定的資深公務員更支持永續運輸相關政策。

關鍵字：政策信仰、資深公務員、一般民眾、永續運輸、Rasch 模式、獨立樣本 t 檢定

Empirical Study on Beliefs of Sustainable Transportation Policies

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ABSTRACT

The aim of this study was to develop a conceptual framework to measure stakeholders' policy beliefs on sustainable transportation implementation and then conduct experimental trials aimed at exploring stakeholders' policy beliefs. We conceptualized policy belief as the combined effect of people's objective constraints and subjective considerations, and viewed it as a latent trait. Exploring policy beliefs can provide insights regarding the mindset of those initiating policies and, thus, help predict outcomes prior to implementation. In this study, we first discuss the development of policy beliefs and the factors affecting their development. An effective approach for measuring senior officials' and the general public's policy beliefs is then suggested. Next, we describe an empirical study of the policy beliefs of senior officials and the general public, as well as a comparison of two groups of stakeholders.

This study quantitatively evaluated beliefs about sustainable transportation policies from senior officials and the general public by using the Rasch model since it has been intensively used in psychometric studies to estimate values on an interval scale based on ordinal responses. The results have shown that not only senior officials but also the general public believe that providing a more efficient and friendly public transportation service to attract people's patronage would be more practicable than limiting private car use by increasing usage costs. For the senior officials, the longer an official is in a position the more experience and power he or she will attain; thus, seniority, experience, and power tend to drive policy success. As the officials become more senior they gain more administrative experience and the better they feel they can judge policy feasibility; they are more confident when implementing policy.

Furthermore, by extending the results based on respondents' commuting modes we found the policy preference rankings from the public transport commuters are the

same as from the general public. “Developing new energy sources” was found to be the strategy in which both the private and the public transport commuters were most confident for implementing sustainable transportation policy. However, for people who commuted by private transport and were willing to act to mitigate private transport use, their policy belief regarding *constructing rail transport systems* to achieve sustainable transport was stronger than the public as a whole.

The study also revealed significant differences in policy beliefs between private and public transport commuters after DIF analysis. Public transport commuters are more confident than private transport commuters in the policies that raise usage costs, such as “Congestion Road Pricing on CBD,” “Increase gasoline prices to reduce car use,” and “Increase parking fees to reduce car use.” In addition, to achieve the goal of sustainable transportation, people who commute by private transport are more confident than public transport commuters in policies that “Provide instant traffic information to reduce driving time,” “Subsidize public to modify car by using LPG,” and “Implement electronic toll collection (ETC).” The findings and lessons learned from the two subgroups of people who owned and did not own a passenger car are the same as from the two subgroups of commuters using private and public transport.

In addition, independent samples *t*-tests were used to identify significant differences between senior officials and the public on each item. The result revealed that the public believes more strongly than the senior officials in the effectiveness of *building public transport centers* as a means for achieving sustainable transportation. Except for *constructing rail transport systems*, the public is more optimistic that these policies will benefit sustainable transportation than are the senior officials. In other words, it indicates that senior officials are more conservative than the public regarding whether these policies will benefit sustainable transportation.

Keywords: policy beliefs, the senior officials, the public, sustainable transportation, Rasch model, independent samples *t*-tests

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CHAPTER 1 INTRODUCTION

1.1 Research Motivations

Sustainable development is a beacon that guides all advanced nations, and the transportation sector will naturally follow this global trend. Coming to terms with all the environmental problems caused by transportation is a long-term activity (Huby & Burkitt, 2000; Olsson, 1999; Walton & Farrington, 2000) and developing an environmentally sustainable transport system would be a major step in achieving this far-reaching goal. The design and implementation of transportation policies based on these principles is the unshirkable responsibility of public sector officials, especially the responsible authorities.

However, tackling the diversity of environmental problems associated with transportation will take time. While many studies have explored policy effectiveness, little attention has been given to the feasibility of implementing public policy from the perspective of the officials involved in policy development and implementation. Those individuals must identify and define the problems and develop strategies to address them. Generally, officials need to be confident a policy is feasible if they are to develop a positive attitude toward its implementation. In addition, feasibility is not an absolute; rather, it is a matter of degree and is based on objective constraints and subjective considerations.

The development of sustainable transportation policies often involves interdepartmental and/or central and local government collaboration. It is useful, therefore, to develop coalitions so that the officials responsible for implementation support the core value of sustainable transportation. Senior officials play a key role in determining whether the objectives of sustainable transportation policy can be

realized. They must also be familiar with the strategic details so as to coordinate an agenda and effectively integrate the resources of industry, government, academia, and the private sector.

Many studies have noted the importance of understanding stakeholders' beliefs regarding environmental polices (Harrison & Burgess, 2000; Tarrant & Cordell, 2002), but few have focused on the policy makers themselves, in part, because of a lack of suitable instruments to measure their viewpoints. Exploring policy beliefs can provide insights regarding the mindset of those initiating policies and, thus, help predict outcomes prior to implementation (Chang & Chen, 2009).

In addition, research focusing on the stakeholders' views of sustainable transportation policies is still very scarce. The aim of the present study is to address this gap by examining policy beliefs of stakeholder groups (senior officials and the general public) engaged in sustainable transportation.

Exploring policy beliefs provides valuable knowledge not only for understanding stakeholders' attitudes regarding sustainable transportation policy, but can also benefit implementation. This realization provides an insight into the mindset of stakeholders when initiating sustainable transportation policies, and helps predict the impact before a new policy is implemented (Chang & Chen, 2009). As such, one focus of this study is to develop a conceptual framework to measure the stakeholders' policy beliefs on sustainable transportation implementation and then, using the developed instrument, conduct an experimental trial aimed at exploring stakeholders' policy beliefs. Towards that end, we first discuss the development of policy beliefs and the factors affecting their development. An effective approach for measuring stakeholders' policy beliefs is then suggested, and a study is designed based on this approach. We then

describe empirical studies of the policy beliefs of senior officials and the general public, as well as a comparison of two groups of stakeholders that was performed to ensure the idea and the findings would be convincing and contribute to achieving the above aims.

1.2 Research Objectives

The objectives of the research are to determine differences among stakeholder groups in their policy beliefs, to investigate whether policy beliefs can be used to effectively segregate stakeholders in well-defined groups, and to define those beliefs that contribute most in delineating stakeholder groups.

Towards those ends, this study looks at the nature of policy beliefs of senior officials and their confidence in implementing various strategies for achieving sustainable transportation. We conceptualized policy belief as the combined effect of a senior official's objective constraints (e.g., financial infeasibility) and subjective considerations and viewed it as a latent trait determined, in part, by levels of expertise, seniority or authority, and administrative experience.

Next, policy beliefs related to sustainable transportation from the perspective of the general public would be analyzed using the Rasch model for quantitative evaluation. Some categorical data related to commuting modes and traffic characteristics were also collected from all respondents.

The observations of the public's commuting modes and their willingness to act to reduce private transportation were connected to their policy beliefs related to sustainable transportation policies and produced some meaningful conclusions. Moreover, evaluating the extent to which a measure's meaningfulness can be generalized across subgroups of a population is important. Differential item

functioning (DIF) analysis was applied in this study and concludes the items function differently for respondents from different groups.

Finally, policy beliefs of senior officials and the public were compared for different senior official and general public groups. Moreover, aggregating the subsamples allowed for a comparison with the senior officials or the general public, respectively, to address gaps or differences by examining policy beliefs of stakeholder groups.

1.3 Research Framework

Given the objectives of this study, the research framework is illustrated in Figure 1.1. This dissertation contains seven chapters that are organized as follows. Chapter 1 introduces our research motivations, objectives, and framework. Chapter 2 presents the results of a literature review on sustainable transportation and policy beliefs. “Sustainability” is a complicated concept with multiple and arguable meanings. Transportation issues are increasingly discussed in the context of sustainable development, most commonly under the rubric of sustainable transport (Banister & Button, 1993; Greene & Wegener, 1997; Nijkamp, 1994; Whitelegg, 1993). However, discussions of sustainable transportation are usually limited to the environmental impact of transportation and possible measures to address these effects (Feitelson, 2002). Here we applied policy beliefs as empirical perceptions and normative opinions about relevant sustainable transportation policy questions and/or policy behaviors. Chapter 3 illustrates our methodology to explore the stakeholders’ policy beliefs. Chapter 4 is an empirical study that demonstrates the policy beliefs of senior officials regarding sustainable transportation policies. Chapter 5 is another empirical study that explores the policy beliefs of the general public related to sustainable

transportation policies. Chapter 6 is a comparison of the cognitive processes related to sustainable transportation policy beliefs between senior officials and the public. At the end of the dissertation, in Chapter 7, we provide a discussion of the findings from the policy beliefs of the senior officials and the general public, and propose suggestions for future study.

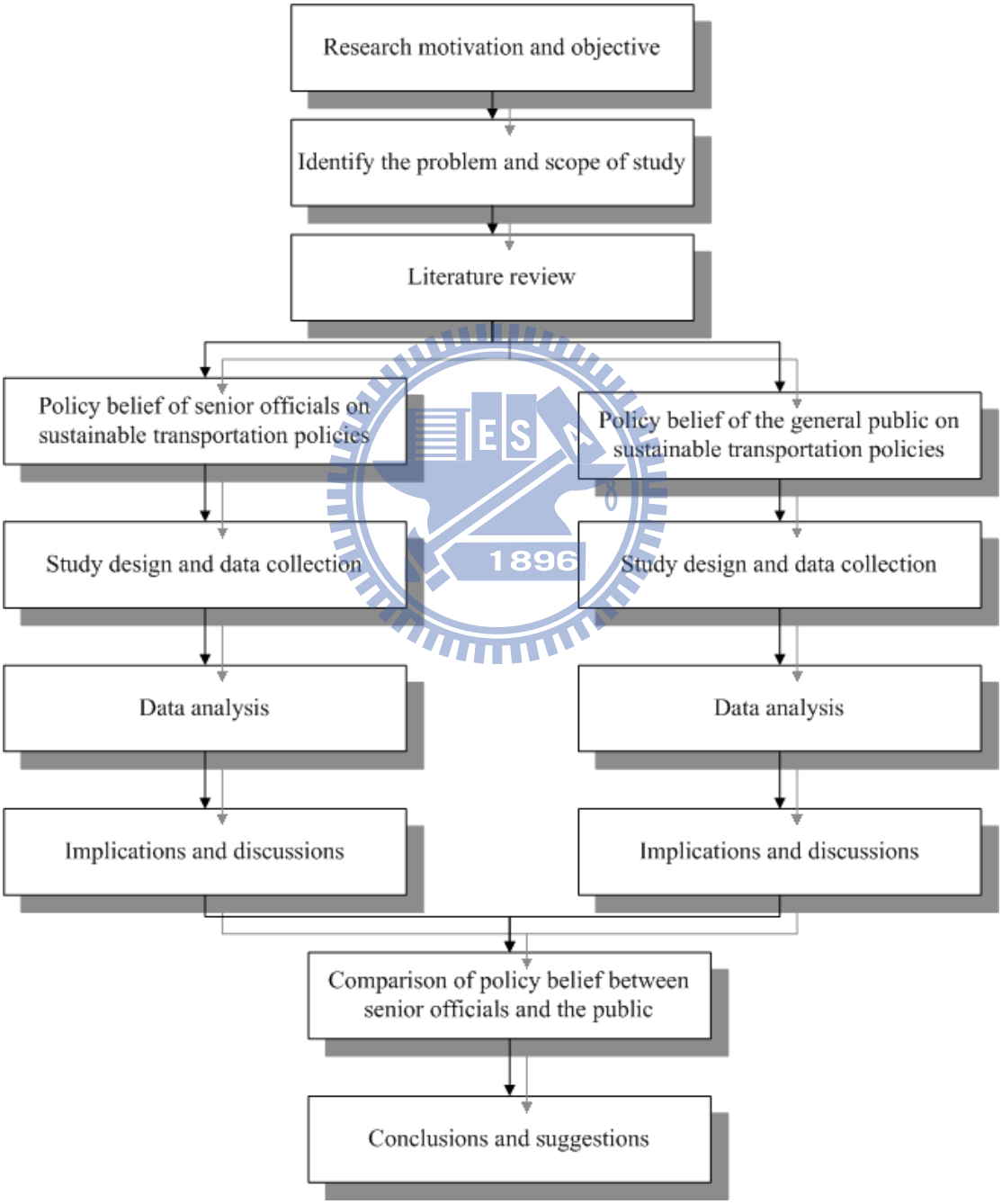


Figure 1.1 Research framework

CHAPTER 2 LITERATURE REVIEW

2.1 Sustainable Transportation Concepts and Policy

The concept of sustainable development has long been implicitly or explicitly accepted as an important component in formulating long-term strategies, although discussions often remained in the qualitative scope. The concept of sustainability emerged in the 1970s as the result of the polarization between advocates of environmental preservation and backers of economic development. At the time, environmentalists claimed that the continued exponential growth in a finite environment would soon meet natural limitations. Gradually, this ‘‘limits to growth’’ argument lost steam and credibility, primarily because it seemed to somehow ignore claims that economic growth was vital in alleviating starvation, disease, and poverty (Torgerson, 1995).

The World Commission on Environment and Development (1987) issued a report that defined sustainable development as ‘‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” This would be “a type of development that integrates production with resource conservation and enhancement, and that links both to the provision for all of an adequate livelihood base and equitable access to resources”. In the Commission’s view, sustainability would require action at the global, national, and local levels. Five years later, at the United Nations Conference on Environment and Development in Rio de Janeiro, representatives of several heads of states embedded the idea of sustainable development into a package of agreements, including a biodiversity convention; a climate change convention; a statement on forest principles; an agreement to work towards a desertification convention, the Rio Declaration on

environment and development; and Agenda 21, an 800-page plan for implementing the Rio Declaration (Ryan & Throgmorton, 2003). Given all of this, considerations of external effects in the environment, stakeholders' equity in society, and efficient use of natural resources in the economy were simultaneously required of all policies of sustainability.

With the exceptions of climate change and atmospheric pollution concerns in urban areas, the emergence of a great number of additional sustainability concerns in recent years (bio-diversity, transport congestion, social exclusion, regional imbalances with their attendant political risks, etc.) have posed particular challenges to analysts with respect to integration and quantification of these problems (Zachariadis, 2005). One of the major issues in this agenda is transportation, which is accepted worldwide as a priority area in sustainability discussions (EEA, 2002; European Commission, 2001; IEA, 2002; WBCSD, 2001; World Bank, 1996). Work on sustainable transport is progressing well both in the research arena and in policy-oriented studies concentrating primarily on emissions of air pollutants (causing health problems) and greenhouse gases (affecting climate change), and is expanding to other sustainability concerns, such as congestion, noise, and accidents. Because of the inherent complexity of this sector in comparison to most other branches of economic activity, and due to the millions of travelers affected, policy measures often have to be viewed at the local level and take into consideration local particularities. In such cases, instead of concrete, quantified proposals, it is necessary to provide policy guidelines only, pointing to successful pilot projects around the world (OECD, 2002).

Additionally, The Organization for Economic Cooperation and Development (OECD, 2002) identified sustainable indicators along a causal generator, namely the "Driving force–State–Response Model," which is adapted to take into account the

specificities of the public sector. The OECD indicators are established according to the tendencies for economic and environmental impact in the various sectors.

2.2 Policy Beliefs

In the process of policy-making, stakeholders bring different types of social values into the partnership process. Not all individuals are good candidates for participating in a collaborative process. Collaborative processes embody a particular set of social values, especially a belief in inclusive public participation, reciprocity, and the belief that environmental and economic values are not mutually exclusive. Another congruent social value is a general belief in consensus-based processes as an appropriate decision-making technique. To the extent stakeholders have social values congruent with the structure and purpose of the relevant policies, they are more likely to cooperate, and less likely use alternative venues to question the effectiveness and legitimacy of any outputs (Lubell & Leach, 2005). To discuss the social values of environmentalism and conservatism, and the possible conflicts between these values, the Advocacy Coalition Framework has been broadly applied by many authors. Case in point: Hovardas and Poirazidis, (2007) examined environmental policy beliefs of stakeholder groups engaged in protected area management and found environmental policy beliefs can be used to effectively divide stakeholders into well-defined segments that override the product-oriented definition of stakeholders. The use of K-means clustering revealed innovation-introduction and implementation-charged sample segments. The instrument utilized in that research proved quite reliable and valid in measuring stakeholders' environmental policy beliefs. Furthermore, the methodology implied that stakeholder groups differ in a significant number of belief-system elements.

In several studies, pro-environmental behavior typically involves a tradeoff between individual and collective benefit, and it has often been conceptualized within models of altruism. In point of fact, Schwartz's (1977) theoretical framework of normative influences on altruism was extended to the environmental domain (Black, Stern, & Elsworth, 1985; Hopper & Nielsen, 1991; Widegren, 1998). In the value-belief-norm (VBN) theory of environmentalism (Stern, 2000; Stern, Dietz, Abel, Guagnano, & Kalof, 1999), pro-environmental behavior is explained by a hierarchical sequence of variables. According to the theory, values, general environmental beliefs (e.g., general problem awareness, awareness of the adverse environmental effects of human actions (awareness of consequences)), and belief that one's own actions could prevent those effects (ascription of responsibility), activate a personal norm. In turn, that personal norm, experienced as a feeling of moral obligation to act, is stipulated to create a willingness to act pro-environmentally (Eriksson, Garvill, & Norlund, 2006).

Different parts of this theoretical framework have been applied to environmentally significant intentions and behaviors. In the New Environmental Paradigm (NEP) (Dunlap & Van Liere, 1978), egocentric beliefs and problem awareness have been found to be positively related to pro-environmental behavior (Nordlund & Garvill, 2002; Stern, Dietz, & Guagnano, 1995; Thompson & Barton, 1994) and the acceptability of different transportation demand management (TDM) measures (Eriksson et al., 2006; Poortinga, Steg, & Vleck, 2002, 2004; Steg & Vlek, 1997). More comprehensively, Nordlund and Garvill (2003) demonstrated the importance of collective values, egocentric values, and problem awareness for a personal norm, which in turn is positively related to willingness to reduce car use. In addition, the full VBN theory has been used to explain acceptability of various energy

policies influencing households (Steg, Dreijerink, & Abrahamse, 2005).

As described by Collantes (2008), policy beliefs here are viewed as empirical perceptions and normative opinions about relevant policy questions and/or policy behaviors. Essentially, empirical perceptions are subjective assessments of cause–effect relationships. Normative opinions are subjective value assessments of policy questions and/or behaviors—they relate to the question of what policy-related behavior should be. Normative opinions are affected by empirical perceptions and by the expectations of relevant sectors of social pressure weighted by the stakeholder's motivation to comply with social pressure.

However, a policy preference is a behavioral intention and it can be defined as the level of support that a stakeholder is ready to give to a specific policy course of action. Reliable measures of true policy preferences are often difficult to obtain. Public statements on policy preferences can be more reliably considered a mix of true policy preferences and strategic behavior. In general, what a stakeholder expresses in a public setting (public hearing, media, conferences, etc.) will be the result of his/her true policy preferences, the coordination with policy allies, and the expectations of the audience (peers, policy-makers, the general public, etc.). Such dissonance between what is true and what is stated may, to some extent, apply to policy beliefs as well.

Following, Collantes (2008), "policy belief" is defined as an individual's level of confidence that a policy is practicable or effective. Presumably, each individual has a unique value representing his/her policy belief regarding sustainable transportation. Such a latent trait can be revealed by the person's answers to items in a questionnaire. That is, people who have stronger beliefs regarding sustainable transportation will

respond with higher scores on a greater number of items than those who have weaker beliefs about the same issues. In addition, some policy strategies might be regarded as better than others in promoting sustainable transportation. Therefore, it can also be presumed that each item has a unique value of inherent resistance against the individual's belief in sustainable transportation.

CHAPTER 3 METHODS FOR MEASURING A LATENT TRAIT

3.1 Review of Item Response Theory

In order to provide objective and valid rating scales for addressing a situation like that outlined above, the item response model was developed and, subsequently, improved. Item response theory (IRT), which is a model-based measurement in which trait level estimates depend on both persons' responses and on the properties of the items that were administered, has become the mainstream of psychological measurement (Hambleton, Swaminathan, & Rogers, 1991). Among the various models of IRT, the Rasch model is one that is widely applied for exploring psychological constructs. A review of IRT and the Rasch model are provided in the following parts of this chapter.

Psychological constructs are usually conceptualized as latent variables that underlie behavior. Latent variables are viewed as unobservable entities that influence manifest variables (e.g., test scores or item responses). Thus, the observation of these manifest variables can only serve as indicators of a person's standing on the latent variables. As a result, measurement of psychological constructs is usually indirect; that is, latent variables are measured by observing behavior on relevant tasks or items. A measurement theory in psychology must provide a rationale that both persons and items on a psychological dimension should be inferred from behavior. Based on such a rationale, IRT was elaborated to serve as a methodology in developing or executing a psychological test.

Item response models are designed to estimate the values of latent variables on an interval scale from item scores that form an ordinal scale. Items scores, or linear combinations of item scores, are called "raw scores". If the raw scores form a

uni-dimensional ordinal scale, then when the data is displayed with the items ordered according to item raw scores (the sum of each subject's responses to a given item) and with the subjects ordered according to individual raw scores (the sum of each subject's responses across all items), the data matrix will conform to a Guttman scale (Guttman, 1950).

A Guttman scale suggests that item raw scores are monotonic with item difficulty, and test scores are monotonic with the subject's ability. The sum of scores across items for each person is the person's raw score and the sum of scores across people for each item is item's raw score. If the raw scores form a Guttman scale, then when people are rank-ordered by person raw score and items are rank-ordered by item raw score, the person rankings are the same for each item and item rankings are the same for each person. There are likely to be inconsistencies with this rigid rule, but the overall statistical pattern of responses should agree with these expectations. The more closely the data agree with the Guttman scale, the more likely it is that the raw scores represent at least an ordinal scale.

3.2 Brief Introduction of the Rasch Model

3.2.1 Formulation of the Rasch Model

The Rasch model has been intensively used in psychometric studies to estimate values on an interval scale based on ordinal responses (Fisher, Harvey, Taylor, Kilgore, & Kelly, 1995; Massof & Fletcher, 2001). To simplify, we initially consider only dichotomous responses; "Do you feel this strategy is practicable for implementing to achieve sustainable transportation?" A score of 1 is assigned to the response "yes", while a score 0 is assigned to the response "no". The probability that a respondent senior official *n* will respond "yes" for Item i is expressed as

$$P(1|\theta_n, b_i) = \frac{e^{\theta_n - b_i}}{1 + e^{\theta_n - b_i}}; \quad (1)$$

and the probability that the response is "no" is expressed as:

$$P(0|\theta_n, b_i) = 1 - P(1|\theta_n, b_i) = \frac{1}{1 + e^{\theta_n - b_i}} \quad (2)$$

Therefore, the odds ratio that a respondent senior official will say "yes" to Item i is

$$\frac{P(1|\theta_n, b_i)}{P(0|\theta_n, b_i)} = e^{\theta_n - b_i} \quad (3)$$

giving the logit specification;

$$\ln \frac{P(1|\theta_n, b_i)}{P(0|\theta_n, b_i)} = \theta_n - b_i \quad (4)$$

that isolates the parameters of interest.

The person and item parameters in the case of dichotomous responses can be estimated from response odds ratios in the data set using the formulation in Equation (4). In addition to dichotomous responses, the Rasch model can be modified to be applicable to polytomous rating-scale instruments, such as a five-point Likert scale (Andrich, 1978; Masters, 1982). The modified Rasch model decomposes a polytomous response into several dichotomous responses, and formulates one multinomial-choice problem into several binary-choice problems. That is, it assigns b_{ix} as the value of the item parameter (i.e., the inherent resistance against belief in this study) for rating category x to Item i, and assumes that Equation (1) refers to the probability of subject *n* responding with rating category *x* rather than *x-1* to Item *i*.

Thus, we can model the log odds of the probability that a person responds in category x for Item i, compared with category x-1, as a linear function of the person parameter (i.e., the person's policy belief in this study) θ_n and the relative parameter of category x, namely, for Item i:

$$\ln\left(\frac{P_{nix}}{P_{ni(x-1)}}\right) = \theta_n - b_{ix} \tag{5}$$

Following Andrich's (1978) modification of the Rasch model for a polytomous response, two types of formulations are widely applied in assessing the values of item and person parameters, namely the "rating-scales model" and the "partial-credit model". The rating-scales model is used for instruments in which the definition of the rating scale is identical for all items, whilst the partial-credit model is employed when the definition of the rating scale differs from one item to another. The partial-credit model differs from the rating-scales model in the possession of its own threshold parameters F_{ix}, for each category k (Wright, 1977). This is achieved by a re-parameterization of Equation (5):

$$b_{ix} = b_i + F_{ix} \tag{6}$$

the partial-credit model can be demonstrated as:

$$\ln\left(\frac{P_{nix}}{P_{ni(x-1)}}\right) = \theta_n - b_i - F_{ix}\,. \tag{7}$$

The partial-credit model (Masters, 1982) is used for items where (1) credit is given for partially correct answers, (2) there is a hierarchy of cognitive demands on the respondents for each item, (3) each item requires a sequence of tasks to be completed, or (4) there is a batch of ordered response items with individual thresholds

for each item. In assessing the policy beliefs of decision makers (DMs), it is not necessary to assume the rating scales of the items are the same; thus, we adopted the partial-credit model for our empirical study.

The Rasch model is regarded as a prescriptive approach rather than a descriptive approach (Bond & Fox, 2001). In other words, the data must fit the model, or the assumptions of the model must be rejected for a particular data set. As a result, some assumptions must be made when we try to apply the Rasch model to measure policy beliefs: (1) people differ in their policy beliefs, (2) people's responses to items depend only on their policy beliefs, (3) responses are probabilistic and conditional on their policy beliefs, and (4) the odds of achieving an item increases monotonically with the difference between the people's policy belief parameters θ_n and the inherent-resistance parameter b_i of the item.

Indices of reliability and validity for assessing a latent construct are also provided by the Rasch model via the person and item aspects, respectively (Wright and Masters, 1982). Reliability indices help us examine whether the model is convincing and the material is replicable, and validity indices help us examine whether the properties of our material are consistent with the assumption of the Rasch model.

3.2.2 Parameter Estimation of the Rasch Model

Based on different statistical assumptions, there are several approaches for estimating the parameters of the Rasch model. Among them, joint maximum likelihood (JML) estimation is a relatively simple and effective approach, which is also the core technique of the related computer programs: WINSTEPS and FACETS

(Linacre and Wright, 1997). A simple introduction of JML estimation is given as follows.

In JML estimation, unknown construct levels are handled by using provisional trait level estimates as known values. The provisional trait level estimates themselves are improved by using subsequently estimated item parameters, which are successively improved. In other words, JML estimation is an iterative procedure that typically involves sequential estimates of person and item parameters. In the initial stage, person parameters are estimated.

The first iteration of the two-stage procedure involves specifying starting values for the item parameters so the maximum likelihood estimates of person parameters can be obtained. Then the item parameters are estimated using the person-parameter estimates. In the following iterations, person and item parameters are iteratively estimated using the improved person or item parameters change very little between the successive iterations (convergence status).

JML has been extensively applied in the estimation of many IRT models and it has several advantages in applications. First, this algorithm is easily programmable. Second, JML is applicable to many IRT models. Both 1PL IRT (e.g. the Rasch model) and 2PL IRT (e.g. the Multi-Facet Rasch Model) can be estimated with JML. Third, JML is efficient on computation. One thing that has to be noted in applying the JML estimation is that there is a strong limitation in applying the JML algorithm. In JML estimation, items or persons with perfect scores (all passed or all failed) provide no information about the parameters because there are no constraints placed on the solution.

Therefore, estimates of such items or persons with perfect scores are not

available in the JML estimation. In fact, measures of items or persons with perfect scores mostly occur in the data of educational tests but rarely in psychological exploration. In psychological exploration, items with perfect scores are regarded as inappropriate because they provide no information about evaluating construct levels of the respondents; a person with perfect scores can be also considered as an ineffective observation because their construct levels are not comparable. It is generally suggested that these items or persons be excluded from the original data or withdraw the data and redesign the whole investigation program.

3.2.3 Reliability and Validity Statistics in the Rasch Model

In latent construct measurement, reliability indices help us to examine whether the model is convincing and the material is replicable, and validity indices help us to examine whether the properties of our material are consistent with the assumptions of the measurement. In the Rasch model, indices of reliability and validity are calibrated respectively via person and item factors (Wright & Masters, 1982) to provide the critical proofs on the quality control of data. We give a brief introduction of these two indices of Rasch measurement in the following paragraphs.

Reliability in latent construct measurement is commonly defined as the consistency of the responses to a set of items or the consistency of scores from the same instrument. Following such that definition, the reliability index *R* in the Rasch model is defined as the degree to which scores are free from measurement error (Andrich, 1988). As a result, the reliability estimate for persons (R_p) is shown (Bond and Fox, 2001) as follows:

$$R_p = \frac{SA_p{}^2}{SD_p{}^2} \tag{8}$$

the total person variability (SD_p^2) represents how much respondents differ on the measure of interest. The adjusted person variability (SA_p^2) represents the reproducible part of this variability (i.e., the amount of variance that can be reproduced by the Rasch model). This reproducible variability is divided by the total person variability to obtain the person reliability estimate (R_p) with values ranging between 0 and 1, which is consistent with the concept of Cronbach's α (Wright, 1996).

On the other hand, reliability for items (R_1) is estimated in the same manner as for persons, in which item variance is substituted for person variance:

$$R_1 = \frac{{SA_1}^2}{{SD_1}^2} \tag{9}$$

Where the total item variability (SD_1^2) represents how much items differ on the measure of interest. The adjusted item variability (SA_1^2) also represents the proportion of total item variability that can be reproduced by the Rasch model.

As noted earlier, the Rasch model is a prescriptive versus a descriptive approach (Bond & Fox, 2001). More specifically, the data must fit the model or the assumptions of the model must be rejected for a particular data set (i.e., the degree to which the previously described properties hold depends on how closely the data fit the model). With the comparison between the observed and expected patterns, two fit statistics, namely information-weighted fit ("infit") and outlier-sensitive fit ("outfit") are generated to evaluate the validity in the Rasch model (Smith, 1991).

The main difference between these two fit-statistics is that he outfit statistic places more emphasis on unexpected responses far from a person's or item's measure, while infit places more emphasis on unexpected responses near a person's or item's measure (Bonds & Fox, 2001). Expected values of these two mean-square fit statistics

are 1, and the guidelines for determining unacceptable departures from expectations remains the focus of many discussions (Smith et. al, 1995). To achieve more generalized standards, both outfit and infit can be further expressed as normalized residuals (Zstd) via a transformation into a *t*-statistic with an approximate unit-normal distribution (Wright & Stone, 1979). A Zstd (Z-standardized fit) statistic has an expected value of 0 and a variance of 1, which has previously been used to select items at the 0.05 significance level and according to the ± 2 criteria.

CHAPTER 4 EXPLORING SENIOR OFFICIALS' POLICY BELIEFS REGARDING SUSTAINABLE TRANSPORTATION

4.1 Introduction

A policy is a statement by a government indicating what it intends to do or not do (Tuominen and Himanen, 2007). A considerable number of studies (Cai et al., 2008; Konidari & Mavrakis, 2007; Lund, 2007) have been made on policy validity or policy effectiveness. However, little attention has been given to the feasibility of policy implementation from the perspectives of those serving in public sectors. In the policy formation process, senior officials are responsible for setting policy and making the related critical administrative decisions. In facing the alternatives, senior officials must first clarify the problem and its causes. Strategies are then proposed through a number of management/motivational measurements. If senior officials are confident, and believe the policy or strategy is feasible, they will have a positive attitude towards implementation; otherwise, they are reluctant to take action. Senior officials might have some degree of confidence in the policy owing to both objective constraints and subjective considerations. Therefore, the term "policy belief," derived from Collantes (2008), is defined here as senior officials' empirical perceptions or subjective opinions about their confidence that the policy is practicable.

For the development of sustainable transportation, relevant policies may be interdepartmental and even require the collaboration of central and local governments. Therefore, government functionaries and officials responsible for the implementation of sustainable development measures must be supportive of the core value of sustainable transportation. Senior officials involved in the implementation of sustainable development strategies serve a key role in determining whether the

concept and meaning of sustainable transportation can truly be realized. They must also be familiar with the details of the strategies in order to coordinate an agenda and effectively integrate the resources of industry, government, academia, and the private sector, and put them to good use.

Although the importance of understanding stakeholder beliefs regarding environmental policy have been noted by many authors (Harrison & Burgess, 2000; Stoll-Kleemann, 2001; Tarrant & Cordell, 2002), research focusing on senior officials' viewpoints is still very scarce and there is a lack of instruments to measure them. Exploring policy beliefs provides valuable knowledge not only for understanding senior officials' attitudes regarding sustainable transportation policies, but can also benefit implementation. This realization provides insights into the mindset of senior officials when initiating sustainable transportation policies, and helps predict their impact before being implemented.

4.2 Questionnaire Design

Latent constructs are commonly explored by means of appropriate questionnaires that include items that portray the target constructs well and stimulate the respondents to effectively report their true feelings or thoughts. Since there was no available relevant questionnaire, a new questionnaire was formulated with items generated on the basis of proposed strategies. To ensure items in this questionnaire could motivate and guide respondents to express their true considerations and judgments on pursuing sustainable transportation, each responding official was asked, "How confident are you these strategies can achieve the goal of establishing a sustainable transportation environment?"

A well-designed questionnaire should provide an opportunity for respondents to

express their degree of feeling or judgment for each item. Therefore, the items used to measure the latent construct of policy belief were responded to on an ordinal scale, using a five-point Likert-type scale anchored by “Strongly Disagree” (coded as 1) and “Strongly Agree” (coded as 5). However, since ordinal data cannot be directly used for statistical inference, owing to violating the property of additivity, a special technique was needed to transfer these ordinal responses onto an interval scale in order to provide a comparative basis for further discussion.

4.3 Rationale for Applying the Rasch Model for Measuring the Policy Belief

Presumably, each senior official has a unique value representing his/her policy belief regarding sustainable transportation (the person parameter). Such a latent trait can be revealed by the person’s answers to the items in a questionnaire. That is, senior officials who have stronger beliefs regarding sustainable transportation will respond with higher scores on a greater number of items than those who have weaker beliefs about those issues. In addition, some policy strategies might be regarded as better than others in promoting sustainable transportation. Therefore, it can also be presumed that each item has its unique value of inherent resistance (the item parameter b_i) against the officials’ belief in sustainable transportation. Items with lower levels of inherent resistance are those strategies that are considered by the officials as more suitable for promoting sustainable transportation.

To better illustrate our formulation of the measures of person and item parameters, a simple example is shown in Figure 4.1. The right side of Figure 4.1 presents the relative levels of policy belief for three senior officials. Joe has the highest level of policy belief and Tom has the lowest. The left side of Figure 4.1

shows the relative inherent resistance of two proposed strategies for promoting sustainable transportation. This example indicates that “slowing down the growth of automobile use” has higher resistance against the belief in sustainable transportation than “improving public transportation systems”. Under the assumption that the item parameters are independent of the person parameters, some conclusions can be drawn from the information provided in Figure 4.1. Namely, all three senior officials tend to believe that “improving public transportation systems” would be more feasible in promoting sustainable transportation than “slowing down the growth of automobile use” because the former has lower inherent resistance against the belief of sustainable transportation.

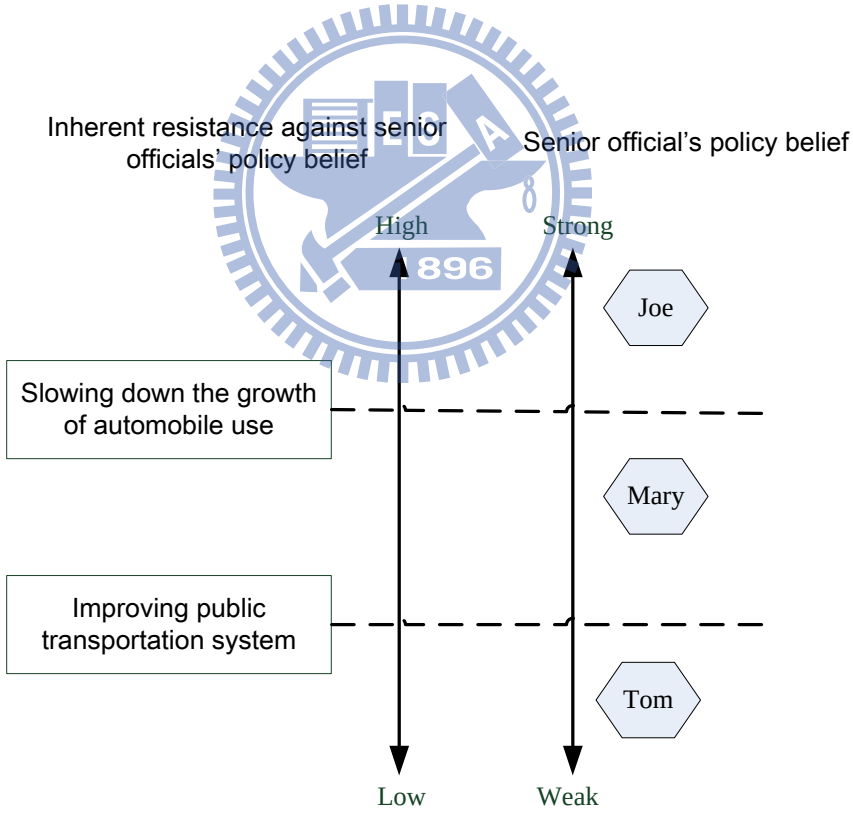


Figure 4.1 Conceptual example of senior officials’ policy beliefs, and the inherent resistance of two strategies in promoting sustainable transportation (modified from Chang & Wu, 2008)

On the other hand, the person parameters of Joe, Mary, and Tom are in order from high to low according to the magnitudes of their policy beliefs in sustainable transportation. Therefore, for any specific alternative, Joe will believe it to be more feasible than Mary and Tom because he has a higher belief in sustainable transportation than the other two persons. If we consider the above characteristics, it is apparent that the difference between the person parameter and the item parameter b_i will determine the tendency of the senior official's *n*'s consideration of the policy strategy *i*. This tendency could then be formulated as a function of a probability and determined by the value.

In order to provide a theoretical basis for comparisons, the person parameters (policy beliefs) and item parameters (inherent resistance against the policy belief) must be measured on a consistent interval scale. However, all of the responses of senior officials to the questionnaire were collected on an ordinal scale in order to provide room for respondents to describe their judgments more precisely. Therefore, a statistical technique to convert the ordinal raw data into data on an interval scale was needed; thus, we chose the Rasch measurement model (Rasch, 1960) for the purpose of this study.

4.4 Design of the Empirical Exploration on Senior Officials' Policy Beliefs

4.4.1 Empirical Questionnaire Design

To demonstrate our conceptual framework and measurement approach for policy belief, an empirical study was carried out to explore senior officials' beliefs regarding sustainable transportation policies. The questionnaire was designed based on 13 items collected from the extant literature (MOTC, 2006), which are strategies that benefit

sustainable transportation (Table 4.1). These 13 strategies were selected from the conclusions of transportation sector initiatives of the 2nd National Energy Conference in Taiwan. All 13 items were responded to on a five-point Likert-type scale, namely "Strongly Agree", "Agree", "Neutral", "Disagree", and "Strongly Disagree". The responses in these five categories, from "Strongly Agree" to "Strongly Disagree" for each item, represented the respondents' feelings about each strategy's practicability for sustainable transportation policy from high to low, respectively.

Table 4.1 Content of the questionnaire for the senior officials

Items to explore self-rated perceptions		Type
Using the scale provided, please indicate the extent to which you are confident these strategies can achieve the goal of establishing a sustainable transportation environment?		
Item 1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation.	5-point scale
Item 2	Build public transport centers to facilitate transfer between different public transportation modes.	5-point scale
Item 3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfers easier.	5-point scale
Item 4	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth.	5-point scale
Item 5	Increase gasoline prices to reduce car use.	5-point scale
Item 6	Increase parking fees to reduce car use.	5-point scale
Item 7	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emissions.	5-point scale
Item 8	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality.	5-point scale
Item 9	Import public transportation that uses substitute energy, such as natural gas, electricity, or combination-hybrid to reduce fossil fuel use.	5-point scale
Item 10	Develop new energy sources (electric cars, fuel-batteries, etc.) to substitute for the use of fossil fuel.	5-point scale
Item 11	Establish bicycle lanes to promote the use of bicycles.	5-point scale
Item 12	Build a friendly walking environment to reduce the use of private modes.	5-point scale
Item 13	Encourage public and private firms to use public transport to slow the use of cars and motorcycles.	5-point scale
Respondent's personal characteristics		
Gender (male, 0; female, 1) binary response		
Age category response		
Seniority category response		
Education category response		

4.4.2 Data Collection

Data were obtained from participants in on-the-job training programs designed for senior officials. The on-the-job training programs hosted by the National Civil Service Institute in Taiwan are designed to improve administrative efficiency, enhance administrative effectiveness, increase the number and scope of the nation's competitive advantages by developing a world-class workforce of senior officials, and lay a firm foundation for the continued development of democratic politics. The data for this empirical study were collected by investigating 143 senior officials from federal to local governments engaged in relevant sustainable development sectors. These senior officials are all experienced in a relevant field, familiar with the sustainable issue and, more importantly, involved in the implementation of sustainable development action plans.

The respondents' self-rated scores for each item and their personal characteristics were gathered through their completing the questionnaire with the assistance of well-trained investigators. Of these 143 respondents, 104 (72.7%) were male and 39 (27.3%) were female and their average age was 46.4 years. Categorical data related to seniority and level of education were also collected from all respondents.

4.4.3 Application of Rasch Analysis

The Rasch measurement model provides a means for constructing interval measures from raw ordinal category data. On the basis of the Rasch model, a value on an interval scale was estimated for each item (i.e., the item parameter) and for each respondent (i.e., the personal parameter). The responses of the 143 senior officials for the 13 items were analyzed with WINSTEPS (Linacre and Wright, 1997), an iterative computer program that estimates θ_n for senior official n and b_i for item i in

logit units. WINSTEPS deals with polytomous responses by applying the Masters–Andrich modification (Masters, 1982) of the Rasch model. The estimated parameters and model fit statistics could, therefore, be calibrated via a joint maximum-unconditional-likelihood estimating procedure (Wright, 1996).

The estimated parameters and fit statistics for the entire Rasch model are shown in Table 4.2. The Rasch assessment fixed the average measure of all item parameters at zero logit to be a comparative basis of the relative interval scale; the average value of the policy belief of all respondent senior officials was 0.28 logit. Such a positive value indicates that these senior officials generally have strong beliefs in sustainable transportation policies. Before we start the detailed discussion and interpretations of the estimated item and person parameters, the reliability and validity of this Rasch model must first be discussed.

Reliability is commonly defined as the consistency of the responses to a set of items or the consistency of scores from the same instrument. It is also defined as the degree to which scores are free from measurement errors. The WINSTEPS program provided reliability information for both items and persons, as shown in Table 4.2. The person and item reliability coefficients can be interpreted similarly to a Cronbach alpha reliability coefficient for the internal consistency of responses to items (Wright, 1996). The item reliability index of 0.98 and person reliability index of 0.83 indicate the data are consistent with the assumptions of the Rasch model from the viewpoints of both items and persons.

Table 4.2 Model estimation and fit statistics obtained from Rasch analysis for the senior officials

Items 13 Input 13 Measured						
	Raw score	No. of observations	Measure	SE	Infit Zstd	Outfit Zstd
Mean	472.8	143	0.0	0.09	0.1	0.1
						Item Reliability: 0.98
Persons 143 Input 143 Measured						
	Raw score	No. of observations	Measure	SE	Infit Zstd	Outfit Zstd
Mean	43.0	13	0.28	0.31	–0.2	–0.1
						Person Reliability: 0.83
Standardized Residual variance (in eigenvalue units)						
					Empirical (%)	Modeled (%)
Total variance in observations				35.2	100	100
Variance explained by measures				22.2	63.0	63.3
Unexplained variance (total)				13.0	37.0	36.6
Unexplained variance explained by 1st factor				2.9	8.3	
Unexplained variance explained by 2nd factor				2.4	6.7	

[a]SE, standard error; Infit, information-weighted fit; Outfit, outlier-sensitive fit; Zstd, *Z*-standardized fit statistic.

Validity refers to the creation or selection of items to measure the same construct when performing a measurement of a latent characteristic. The validity information is expressed by the fit statistics in a Rasch measurement. Based on a comparison of the expected and the observed patterns, the fit statistics aid in quality control and in identification of data that do not meet the requirements of the model. Two fit statistics were estimated by WINSTEPS, namely an information-weighted fit ("infit") and outlier-sensitive fit ("outfit") (Smith, 1991). The infit and outfit are expressed as normalized residuals in Table 4.2. The *Z*-standardized fit statistic (Zstd) has

previously been used to select items at the 0.05 significance level and according to ±2 criteria. In our model, the infit and outfit statistics of the estimated parameters for both persons and items are all close to zero, which implies that the overall validity of our model is acceptable.

4.5 Findings and Interpretations

4.5.1 Findings for Item Parameters

Estimates of the item parameters are displayed in Table 4.3. The first column contains a description of each item; the second contains the raw score (a linear combination of item scores with a possible scale range of 143–715 for each item; the third shows the estimate for each item; and the fourth and fifth show the infit and outfit statistics, respectively, which provide evidence to determine the validity of each item. The fit statistics for these 13 items are all in the ±2 range, which implies the item responses do not deviate significantly from the assumptions of the Rasch model. The items in Table 4.3 have been ordered by their estimated values for comparison purposes.

All estimates from a Rasch model are relative. It is generally suggested that the average of all item estimates should be fixed at zero logit; therefore, the estimates for all the items and persons have been calibrated with reference to the average item estimate. The items with lower raw scores are those strategies that, for these officials, are generally considered as having lower levels of belief regarding the possibility of implementation for sustainable transportation policy. That is to say, items with higher estimates (i.e. strategies with higher inherent resistance against policy belief) are those strategies that are generally considered to be more difficult to achieve for these senior officials; items with lower estimates are those strategies that are generally

considered to be more feasible.

Table 4.3 Estimates of item measures and fit statistics from Rasch analysis for the senior officials

	Item	Raw Score	Estimate (b_i)	Infit Zstd	Outfit Zstd
1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation.	617	-1.33	0.4	1.2
2	Build public transport centers to facilitate transfer between different public transportation modes.	583	-0.89	0.3	-0.5
10	Develop new energy sources (electric cars, fuel-batteries, etc.) to substitute for the use of fossil fuel.	555	-0.60	1.1	0.6
3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfers easier.	546	-0.52	0.7	0.3
9	Import public transportation that uses substitute energy such as natural gas, electricity, or combination-hybrid to reduce fossil fuel use.	531	-0.39	0.0	0.1
12	Build a friendly walking environment to reduce the use of private modes.	525	-0.34	-1.5	-1.7
11	Establish bicycle lanes to promote the use of bicycles.	515	-0.26	-0.5	-0.6
13	Encourage public and private firms to use public transport to slow down the use of cars and motorcycles.	467	0.11	-1.3	-0.3
4	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce automobile growth.	403	0.55	1.4	1.8
8	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality.	391	0.63	-0.2	-0.3
7	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emissions.	352	0.91	0.4	0.4
6	Increase parking fees to reduce car use.	333	1.05	0.3	0.3
5	Increase gasoline prices to reduce car use.	328	1.08	0.2	0.2

The item parameter estimates for the 13 strategies on sustainable transportation policy are shown in Table 4.3, Item 5 (Increase gasoline prices to reduce car use) and Item 6 (Increase parking fees to reduce car use) have the two highest estimate values

of 1.08 logit and 1.05 logit, respectively. Those results indicate that increasing the cost of using automobiles, by increasing gasoline prices or parking fees, have the highest inherent resistance and, therefore, result in the lowest levels of confidence as practicable strategies to achieve sustainable transportation policy. On the other hand, the items with the two lowest estimates are “Construction of rail transport systems to promote public transportation” (Item 1; b_i = -1.33) and “Build public transport centers to facilitate transfer between different public transportation modes” (Item 2; b_i = -0.89). These results show that senior officials believe that promoting and improving public transportation are the most feasible strategies and are confident in their benefiting sustainable transport.

Items 3, 9, 10, 11, and 12 are the other five items with negative estimates. As such, improving energy efficiency, by developing new energy sources to substitute for the use of fossil fuel (Item 10) and importing public transportation that uses substitute energy such as natural gas, electricity, or combination-hybrid to reduce fossil fuel use (Item 9), as well as enhancing transportation demand management, such as integrating schedules and tickets for public transportation to making transfer easier (Item 3), building a friendly walking environment to reduce the use of private modes (Item 12), and establishing bicycle lanes to promote the use of bicycles (Item 11), would make the senior officials feel confident that the strategies are comparatively practicable. Items 4, 7, 8, and 13 (i.e., those with positive estimates) indicate that senior officials lack confidence in implementing strategies on sustainable transportation policy by reducing traffic flow and private vehicle ownership.

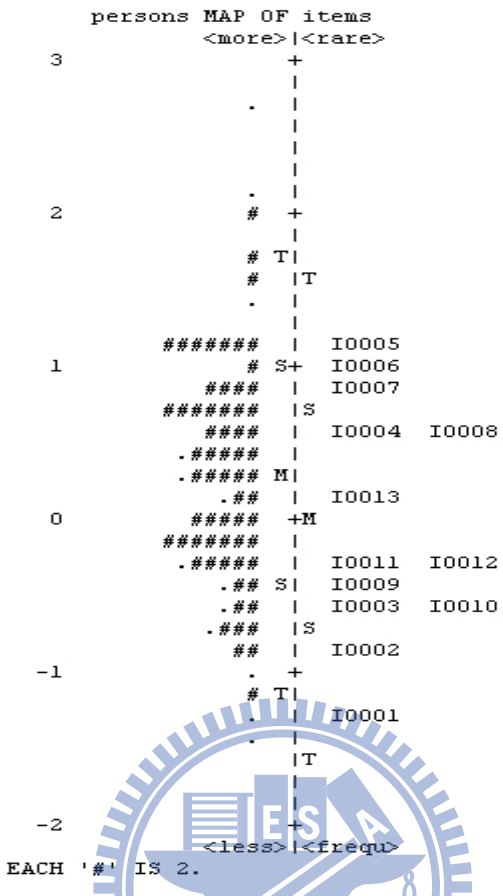
It also reveals that only three items (4, 5, & 6) with lower ranking in the Table 4.3 were viewed as restrictive strategies to limit the demand of private cars use; others were encouraging strategies to emphasize the supply of better transportation

alternatives. It is clear from the data, senior officials are not inclined to restrict people's freedom to drive in order to implement the sustainable transportation development.

We can also concluded that senior officials believe providing a more efficient and friendly public transportation service to attract people's patronage would be better than limiting private car use by increasing usage costs based on practice and experience. Thus, in order not to infringe on personal preferences and freedoms, the officials will support strategies that provide the option for people to make a choice to use public transportation but will not support strategies that force people to use public transportation.

4.5.2 Findings for Person Parameters

The Rasch model also helped us to estimate the self-rated policy beliefs of the 143 senior officials who participated in this study. The self-rated policy beliefs of these 143 senior officials were estimated from 1.37 to 2.75 logit by the Rasch model. Since the item and person parameters are both measured on the same interval scaled unit of "logit", where the difference between the item and person estimates has a consistent meaning. The item-person map (as shown in Figure 4.2), which plots the values of all item and person parameters together, provides a straightforward and graphic illustration to disclose the relevant information behind the cross comparison between person and item parameters.



Note: (1) “M”: mean measure.

(2) “S”: one sample standard deviation.

(3) “T”: two sample standard deviation.

Figure 4.2 Item-person map for the responded senior officials

The left field of the item-person map indicates the distribution of the self-rated policy beliefs of the responding senior officials. The levels of sustainable transport policy belief are in order from top to bottom. The number of respondents located at each level is represented by the combinations of the “#” and “.”, and the respondents located in higher positions indicate their levels of sustainable transport policy belief are relatively high. The right field of the map shows the item estimates, which represent inherent resistance to belief in sustainable transport development policy. When an item is located at a higher position along the vertical axis it is thought to be a

tougher strategy for senior officials to achieve as a sustainable transport development policy. For the values of both person belief and item inherent resistance, it is common to anchor the average value of all item parameters at zero logit to provide the basis for cross comparison. When a senior official and an item are located at the same level on the item-person map, he/she will have the probability of 0.5 to feel it is a practicable strategy to achieve sustainable transport development. If most respondents' beliefs are located at positions higher than the estimate of one specific item, it implies that this strategy is considered to be relatively practicable by those respondent officials.

According to the estimates shown on the item-person map (see Figure 4.2), we can see that Item 5 (Increasing gasoline prices to reduce car use) is viewed as being the most difficult strategy to implement and only 16% of the responding senior officials felt they could achieve it with ease and only 16% of the responding senior officials felt confident they could achieve this strategy for sustainable transport development. Item 6 (Increasing parking fees to reduce car use) and Item 7 (Implementing electronic toll booths on highways to reduce oil consumption and improve air quality) are viewed as the next two most difficult strategies, and only about 23% of the senior officials believed they could achieve sustainable transport development by implementing these two strategies. However, we can see that more than 64% of the respondent senior officials believed they could achieve sustainable transport policy by implementing those seven strategies with negative item estimates (i.e., Items, 1, 2, 3, 9, 10, 11, & 12), and more than 94% of senior officials felt they could achieve sustainable transport development by implementing the strategies of Item 1 and Item 2. Thus, the proportion of senior officials who are confident in a specific strategy to achieve sustainable transport development can be easily identified by applying the item-person map.

The interval scale property of Rasch measurement also enables us to extend the results for further explorations. By relating each respondent's measure of policy belief to his/her level of seniority, some useful information can be easily observed from Figure 4.3. Each respondent's years of seniority and policy belief measure (logit) are diagrammed on the horizontal and vertical axes, respectively, in Figure 4.3. On the horizontal axis, the respondents are divided into five subgroups based on their years of seniority, namely 10~14, 15~19, 20~24, 25~29 and 30+. An obvious positive correlation emerged between seniority and policy belief measures of senior officials. Apparently, the categories with higher seniority reflect higher policy beliefs. Such an observed relation can easily be verified owing to the property of interval-scale measures offered by the Rasch measurement.

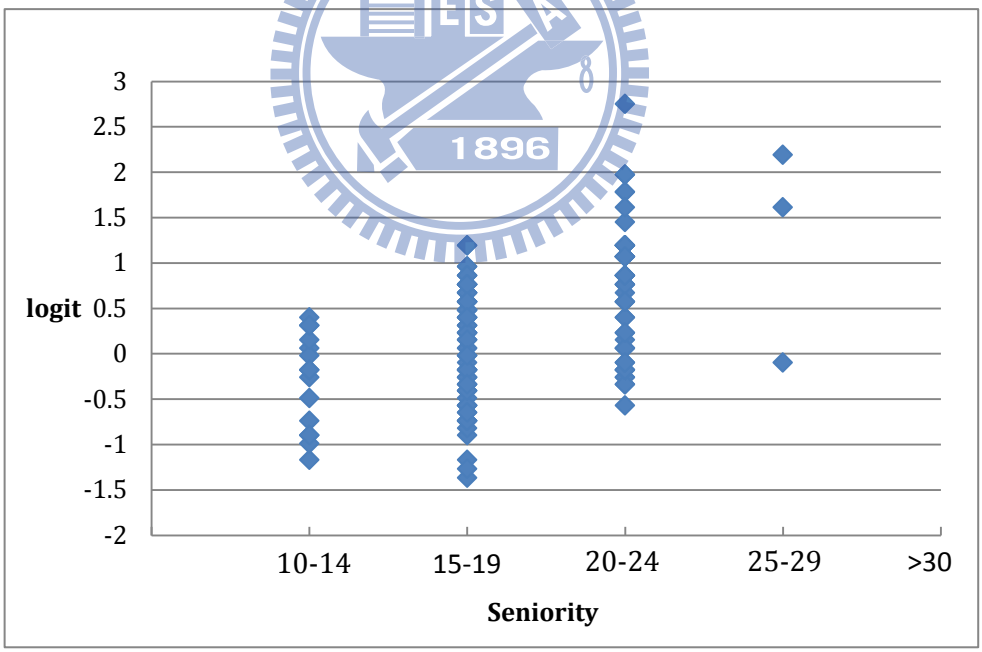


Figure 4.3 Distribution of the seniority and policy belief measures of the respondent senior officials

The correlation ratio, Eta (η), is the percent of total variance in the dependent variable accounted for by the variance between categories (groups) formed by the

independent variable(s). The correlation ratio η between the seniority and policy belief measures was 0.503, which indicated policy beliefs become stronger as senior officials gain more experience. The most likely explanation is that the longer a person is in a position the more power he or she attains; thus, the relationship between seniority and power tends to drive policy success. As the officials become more senior the more administrative experience they have and the better they can judge policy feasibility and are more confident when implementing policy. However, senior officials' beliefs were not found to be significantly related to either their gender or education.

4.6 Discussion

In this chapter, policy belief was conceptualized as the combined effect of a senior official's objective constraints and subjective considerations, and was thought of as a latent trait that is determined by level of expertise, seniority or authority, and administrative experience. The Rasch model was used to estimate the parameters on an interval scale based on the ordinal raw data collected via the questionnaire. The application of the Rasch model enabled us not only to estimate each senior official's policy beliefs, but also identify the practicability of each strategy to achieve sustainable transportation development. Moreover, the item-person map provides a straightforward and graphic illustration to reveal the relevant information behind the cross comparison between person and item parameters, which is useful for determining what proportion of senior officials are more (or less) confident in utilizing certain strategies. An empirical analysis of policy beliefs was performed by using self-rated information about 13 items (strategies), contained in responses from 143 senior officials. Convincing results from this empirical study supported our

conceptual framework related to policy belief. This study introduced the previously unexplored aspect of the psychological nature of policy beliefs, suggested an operational method to measure such a latent construct, provided information about senior officials' confidence in implementing the strategies to achieve sustainable transportation policy, and offered insights into senior officials' attitudes regarding sustainable transportation.

Examining the policy beliefs of senior officials not only provides valuable knowledge regarding their levels of confidence in implementing sustainable transportation policies, it also provides insights regarding the impact of sustainable transportation policies prior to implementation. In general, when senior officials are confident that a policy or strategy is feasible they will be more inclined to support its implementation, and conversely.

The study results show that items related to promoting and improving public transportation were found to be the strategies in which senior officials were most confident when implementing sustainable transportation policy. Strategies aimed towards improving energy efficiency and enhancing transportation demand management to improve the efficiency of the urban transportation systems through operational improvements make the respondents feel confident and believe that the strategies are comparatively easy to implement. We also found that items related to increasing the costs of using automobiles, such as increasing gasoline prices or parking fees, make senior officials less confident in their ability to achieve that type of sustainable transportation policy. Thus, we can concluded, based on practice and experience, senior officials believe that providing a more efficient and friendly public transportation service to attract people to their use would be better than limiting private car use by increasing usage costs. Furthermore, the officials are more likely to

support strategies that do not infringe on personal preferences and freedoms. More specifically, people enjoy the personal freedom brought by their cars, and none of them want to be limited in their use of them or be told that it will cost more to use them. So, in order not to have the public angry at their decisions, the officials will support strategies that provide the option for people to make a choice to use public transportation but will not support strategies that force people to use public transportation. None of these officials want to be seen as a "bad guy" so they are likely to take the path of least objection from the public.

There are some important implications here for the future implementation of a sustainable transportation policy. First, as discussed above, these officials tend to want to neither displease the public nor support thankless strategies that infringe upon the rights of people, which is why they prefer providing public transportation services to limiting private car use. However, developing and promoting public transport benefits energy intensity improvement but it takes a long time, it is difficult, and it is too expensive. Huby and Burkitt (2000) showed that improving public transport alone does not seem to be enough to make a significant difference in car use. That is, public transport should be given more priority but it should not be the only means to solve transport problems towards sustainable transportation.

Next, constructing public transport could not be completed in a short timeframe. Economic means (such as increasing usage costs) to limit private car use is indispensable to sustainable transportation for a short-term period. If the senior officials have lower confidence in the strategies related to increasing gasoline prices or parking fees, it does not mean the strategies of increasing the costs of using cars are not worth pursuing. On the contrary, people's choice of transportation is often a function of alternatively using a carrot and a stick. Administrators, through proper

rewards and punishment, inform people which behaviors are not allowed, and conversely. The senior officials responsible for setting policy should be more positive in evaluating the costs and benefits of alternative strategies. If the senior officials cannot understand the necessity of using economic instruments to reduce traffic, they need to be reeducated.

Of all the responding senior officials, only 16% believed that *increasing gasoline prices to reduce car use* would be an easy policy to implement. The same observation applies to the strategies related to *implementing electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emissions* and *increasing parking fees to reduce car use*. Only about 23% of the senior officials had confidence in being able to implement them easily. On the other hand, more than 94% of senior officials believe that *constructing rail transport systems to promote public transportation* and *building public transport centers to facilitate transfer between different public transportation modes* are the best two strategies to benefit sustainable transportation policy.

Another interesting finding in this study shows that there is a positive relation between policy beliefs and the seniority of senior officials. As officials gain seniority, they have more power of judgment to evaluate the feasibility of policies because of accumulated administrative experience. However, we cannot wait for officials to gain seniority. Administrative organizations may need to develop training programs for younger officials to improve their administrative efficiency, raise their administrative effectiveness, and increase the number and scope of the nation's competitive advantages.

4.7 Concluding remarks

Little attention has been given to the point that it is the performance of senior officials that is key to the success of a policy. More than that, instrumentation to measure officials' beliefs seems to be lacking. In our experimental exploration of the self-rated policy beliefs of senior officials, we used Rasch assessment to assess this latent trait. Some other approaches, such as factor analysis and path analysis, are also widely applied in measuring latent constructs related to DMs. However, those approaches accept raw scores at face value and rely heavily on inferential arguments to validate scales that are calibrated. Rasch analysis offers a more reasonable approach to transferring ordinal responses to interval scales, which enables researchers to estimate a latent variable by assessing the performance of each item as a contributor to the measurement. Such an approach is especially useful when one is trying to measure a construct that is not extensively discussed in the literature. Not only can the validity of items for exploring the construct be examined, but also the findings from the measures of both items and persons can be interpreted as useful information.

CHAPTER 5 ASSESSING THE PUBLIC'S POLICY BELIEFS IN SUSTAINABLE TRANSPORTATION

5.1 Rationale behind Applying the Rasch Model to Measure Policy Beliefs

Policies are often based on what governments plan to accomplish (Tuominen & Himanen, 2007) and the effectiveness of policies has been explored in many literature streams (Cai et al., 2008; Konidari & Mavrakis, 2007; Lund, 2007). Many previous studies focused on issues that included the lack of support among key stakeholders, reluctance among policy makers to dedicate themselves to consistent and effective policies, and the lack of understanding of the roots of public attitudes towards specific public policies. Moreover, sustainable development is a global trend and has been pursued by the transportation sector. While dealing with environmental problems caused by transportation is a long-term activity (Huby & Burkitt, 2000; Olsson, 1999; Shiftan, Kaplan, & Hakkert, 2003; Walton & Farrington, 2000), implementing an eco-friendly transport system would be a major step for achieving sustainable development (Parkhurst, 2004). Because sustainable transport policies are strongly related to the people's livelihoods, public support plays a key role in determining whether the objectives of sustainable transportation policies can be realized. If people believe the policies for saving energy and reducing emissions of carbon dioxide are effective, they tend to support the policies and, subsequently, abide by the related strategies (Collantes, 2008).

Many previous studies have noted the importance of understanding stakeholders' beliefs in environmental polices (Harrison & Burgess, 2000; Tarrant & Cordell, 2002), but there is a need to develop an instrument to measure their viewpoints. For the

purposes of this study, and in line with Collantes (2008), “policy belief” is defined as the level of public confidence that a policy is beneficial for achieving the goal of establishing a sustainable transportation environment. The goal of this study is to explore the public’s beliefs in sustainable transportation policies.

5.2 Design of the Empirical Exploration of the Public’s Policy Beliefs

5.2.1 Empirical Questionnaire Design

The public’s policy beliefs can be considered as the latent psychological constructs that influence their motivation for implementing specific strategies to achieve an objective. This section addresses how those latent policy beliefs were assessed. Typically, latent constructs are explored by self-report questionnaires that contain items geared toward stimulating the respondents to report their true thoughts and feelings about the target constructs. The questionnaire for this study was developed based on 15 items collected from the extant literature (MOTC, 2009). More specifically, each of the 15 items was a specific strategy deemed to benefit sustainable transportation (Table 5.1). In order to guide respondents and motivate them to express their true judgments, each was asked, “How confident are you that these strategies can achieve the goal of establishing a sustainable transportation environment?” Reponses to the 15 questionnaire items were provided on a five-point Likert-type scale, ranging from 1 = “Strongly Disagree” to 5 = “Strongly Agree”.

Table 5.1 Content of the questionnaire for the public

Items to explore self-rated perception		Type
Using the scale provided, please indicate the extent to how confident are you in these strategies can achieve the goal of establishing a sustainable transportation environment?		
Item 1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	5-point scale
Item 2	Build public transport centers to facilitate transfer between different public transportation modes	5-point scale
Item 3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	5-point scale
Item 4	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	5-point scale
Item 5	Develop new energy sources (electric cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	5-point scale
Item 6	Establish bicycle lanes to promote the use of bicycles	5-point scale
Item 7	Build a friendly walking environment to reduce the use of private transport modes	5-point scale
Item 8	Increase gasoline prices to reduce car use	5-point scale
Item 9	Increase parking fees to reduce car use	5-point scale
Item 10	Encourage public and private firms to use public transport to slow the use of cars and motorcycles	5-point scale
Item 11	Subsidize the public to modify cars by using LPG	5-point scale
Item 12	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emissions	5-point scale
Item 13	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	5-point scale
Item 14	Ramp metering and HOV lane for freeways	5-point scale
Item 15	Congestion Road Pricing on CBD	5-point scale
Respondent's personal characteristics		
Gender (male, 0; female, 1) binary response		
Age category response		
Education category response		
Commute mode category response		
Willingness to act to mitigate private transport use		5-point scale

5.2.2 Data Collection

A survey, used during face-to-face interviews with the public, was carried out via a street investigation in Taipei City. A number of well-trained investigators were sent to several main bus and MRT stations, as well as gas stations, in Taipei. The goal was to equally sample respondents using public and private modes of transportation. The respondents' self-rated scores for each item and their demographic characteristics were also gathered. After eliminating invariant, inconsistent, and incomplete responses, 487 of the questionnaires were retained for analyses. Of the 487 respondents, 283 (58.1%) were male and 204 (41.9%) were female; their average age was 33.6 years. Information about each respondent's travel expenses, occupation, level of education, commuting modes, and willingness to act to mitigate private transport use was also collected.

5.2.3 Application of Rasch Analysis

The choice of analytic technique used for the data generated by the sample from the general public, and the reasons for that choice, are the same as those for the sample of senior officials. As such, and in order to avoid redundancy, the details of the theoretical underpinning of the Rasch approach, the assumptions of the model, the choices of fit statistics to report, and the computer programs used for the analyses will not be repeated in this section. Only those facets of the analyses that are unique to the general public sample and the results of those analyses will be provided.

Presumably, each person (n) has a unique value representing his/her policy belief in sustainable transportation (the person parameter θ_n). That latent trait can be revealed by the person's answers to items in a questionnaire. In other words, those members of the public with stronger beliefs in sustainable transportation will respond

with higher scores on more items than those who have weaker beliefs. Also, some policies might be considered as contributing more to the promotion of sustainable transportation than others. Therefore, it can also be presumed that each item (i) has its unique value of inherent resistance (the item parameter b_i) against the public's belief in sustainable transportation. Items with lower inherent resistance are the strategies that the public consider more suitable for promoting sustainable transportation.

Tests for Uni-dimensionality

Uni-dimensionality is a fundamental assumption in the Rasch model and indicates that subject responses are based on one latent trait. However, the requirement of uni-dimensionality is rarely fulfilled (Hambleton et al., 1991; Rubio, Aguado, Hontangas, & Hernandez, 2007). Instead, exploratory factors analysis (EFA) or confirmatory factor analysis (CFA) is conducted to assess whether the scales have "essential" or "sufficient" uni-dimesionality (Reeve et al., 2007; Rubio et al., 2007; Scherbaum, Finlinson, Barden, & Tamanini, 2006).

In this study, EFA was applied as the first step, because items were not drawn from an item pool based on the literature. As shown at the bottom of Table 5.2, analytical results demonstrate that the first factor explains roughly 35.2% of variance; thus, the criterion of 20% is fulfilled (Reckase, 1979).

Item Parameter Estimates and Results of Fit Statistic Analysis

The estimated parameters and fit statistics for the entire Rasch model are shown in Table 5.2. The average of all item parameters was fixed at zero logit as a comparative basis for the relative interval scale, and the average value of the policy beliefs of all the respondents was 1.23 logit. This positive value indicates the public generally have strong beliefs in sustainable transportation policies. Examination of the

other descriptive statistics involving, for example, estimation of relevant Z-standardized fit statistics (Zstd) supports the notion that the observed and expected patterns are sufficiently close to meet acceptance criteria.

Table 5.2 Model estimation and fit statistics obtained from Rasch analysis for the public [a]

Items 15 Input 15 Measured						
	Raw score	No. of observations	Measure	SE	Infit Zstd	Outfit Zstd
Mean	1870.9	487	0.0	0.06	-0.4	0.0
Item reliability: 0.99			Item separation index: 11.8			
Item infit MNSQ: 0.97			Item infit Zstd: -0.4			
Persons 487 Input 487 Measured						
	Raw score	No. of observations	Measure	SE	Infit Zstd	Outfit Zstd
Mean	57.6	15	1.23	0.38	-0.1	-0.2
Person reliability: 0.88			Person separation index: 2.67			
Person infit MNSQ: 1.01			Person infit Zstd: -0.1			
Standardized Residual Variance (in eigenvalue units)						
					Empirical(%)	Modeled(%)
Total variance in observations				35.2	100	100
Variance explained by measures				22.2	63.0	63.3
Unexplained variance (total)				13.0	37.0	36.6
Unexplained variance explained by 1st factor				2.9	8.3	
Unexplained variance explained by 2nd factor				2.4	6.7	

[a]SE, standard error; Infit, information-weighted fit; Outfit, outlier-sensitive fit; Zstd, *Z*-standardized fit statistic.

Item Parameter Estimates and Results of Fit Statistic Analysis

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patterns are sufficiently close to meet acceptance criteria.

Both person reliability and item reliability can be interpreted as Cronbach's alpha reliability coefficients (Wright, 1996) and have values of 0.88 and 0.99, respectively. The widely accepted social science cutoff for Cronbach's alpha is ≥0.70 for an item set (Streiner & Norman, 2004). In this study, both infit Zstd and outfit Zstd ranged ±2, which indicates the observed responses fit the model well (Wright & Linacre, 1994).

Item separation and person separation are also utilized to describe instrument reliability for the sample. As the values of item separation (the person separation index) increase, the number of levels that can be distinguished in the measure increases (Duncan, Bode, Lai, Perera, & Antagonist, 2003). A separation index of 1.50 represents an acceptable level, 2.00 represents a good level, and an index of 3.00 represents an excellent level of separation (Duncan et al., 2003). Analytical results show that both the item separation index (11.8) and person separation (2.67) exceed 2, indicating that items are sufficiently spread to define distinct levels of policy beliefs as measured in logits.

5.3 Findings and Interpretations

5.3.1 Item Parameter Estimates and Fit Statistics

The estimates of item parameters are presented in Table 5.3. The first column contains a description of each item, the second column shows the estimate of each item, the third and fourth columns show that infit statistics for any item derive most information from the responses of the public close to this item, and the fifth and sixth columns show that outfit statistics closely monitor responses from the public towards the extremes of the scale. All item estimates have an Infit MNSQ and Outfit MNSQ

of 0.84~1.20 and Zstd fit statistics between ±2. Both the MNSQ and Zstd fit statistics meet the requirements that MNSQ be in the range of 0.8–1.2 and Zstd is in the range of ±2. Thus, all items can be utilized to measure the latent construct of policy belief from the public. For comparison purposes, we ordered the items in Table 5.3 by their estimated values.

Again, it should be noted that all estimates from the Rasch model are relative. Items with higher estimates (i.e., strategies with higher inherent resistance against policy belief—the positive values) are those strategies that are generally considered to be more difficult to implement; items with lower estimates (the negative values) are those strategies that are generally considered to be more helpful in establishing a sustainable transportation environment.

The estimates of item parameters for the 15 sustainable transportation policies are shown in Table 5.3 and Items 8 and 9 have the two highest estimate values of 1.31 and 1.09 logit, respectively. These values indicate that increasing the cost of automobile usage by increasing gasoline prices or parking fees has the highest inherent resistance and, therefore, result in the lowest levels of confidence as advantageous strategies to achieve sustainable transportation policy. On the other hand, the item with the lowest estimate is Item 5 (b_i = –1.10). That result indicates the public believes that developing new energy sources (electrical cars, fuel-batteries, etc.) to substitute for fossil fuel is the best strategy and they are confident in it benefiting sustainable transport.

Table 5.3 Estimates of item measures and fit statistics from Rasch analysis for the public (ordered by item parameters)[a]

	Item	Estimate (b_i)	Infit Zstd		Outfit Zstd	
			MNSQ	Zstd	MNSQ	Zstd
5	Develop new energy sources (electrical cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	-1.10	1.00	0.1	0.98	-0.2
1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	-1.01	0.89	-1.4	0.91	-1.1
2	Build public transport centers to facilitate transfer between different public transportation modes	-0.86	0.94	-0.7	0.95	-0.6
7	Build a friendly walking environment to reduce the use of private transport modes	-0.80	0.87	-1.6	0.84	-2.1
6	Establish bicycle lanes to promote the use of bicycles	-0.70	0.93	-0.8	0.95	-0.7
3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	-0.50	0.91	-1.1	0.85	-2.0
4	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	-0.04	1.12	1.6	1.15	2.0
12	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emissions	0.12	1.09	1.3	1.20	2.6
13	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	0.25	1.04	0.6	1.05	0.8
10	Encourage public and private firms to use public transport to slow the use of cars and motorcycles	0.34	0.93	-1.1	1.00	0.0
14	Ramp metering and HOV lane for freeways	0.45	0.92	-1.2	0.96	-0.6
11	Subsidize the public to modify cars by using LPG	0.48	1.01	0.1	1.16	2.3
15	Congestion Road Pricing on CBD	0.98	1.06	1.0	1.11	1.8
9	Increase parking fees to reduce car use	1.09	0.98	-0.3	0.96	-0.6
8	Increase gasoline prices to reduce car use	1.31	0.91	-1.5	0.89	-1.8

[a]See Table 5.2 for abbreviation definitions.

Items 1, 2, 3, 4, 6, and 7 also have negative estimates. In other words, those strategies promoting non-private motor transport, including *constructing rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation* (Item 1), *building public transport centers to facilitate transfer between different public*

transportation modes (Item 2), *building a friendly walking environment to reduce the use of private transport modes* (Item 7), *establishing bicycle lanes to promote the use of bicycles* (Item 6), and *integrating schedules and tickets for public transportation to make transfer easier* (Item 3), are supported by the public with confidence. In addition, the public also believe that the strategy of *providing instant traffic information to reduce driving time in order to reduce oil consumption and improve air quality* (Item 4) is effective. However, items 10, 11, 12, 13, 14, and 15 (i.e., those with positive estimates) indicate that public lacks confidence in their usefulness.

Table 5.3 also reveals, because of their lower rankings, that six items (8, 9, 13, 14, & 15) were viewed as restrictive strategies to limit the demand for private car use, while others were thought of as encouraging strategies to emphasize the supply of better transportation alternatives. The data indicate the public is inclined not to want to be restricted in their driving as a way to achieve sustainable transportation.

Based on the results of this study, the public believe that a better way to attract their patronage is by developing efficient and friendly public transportation rather than limiting private car use by increasing usage costs. In other words, to avoid infringing on their own preferences and freedoms, the public would support strategies that provide the *option* for people to use public transportation, but will not support the strategies that *force* people to use public transportation.

5.3.2 Person Parameter Estimates and Fit Statistics

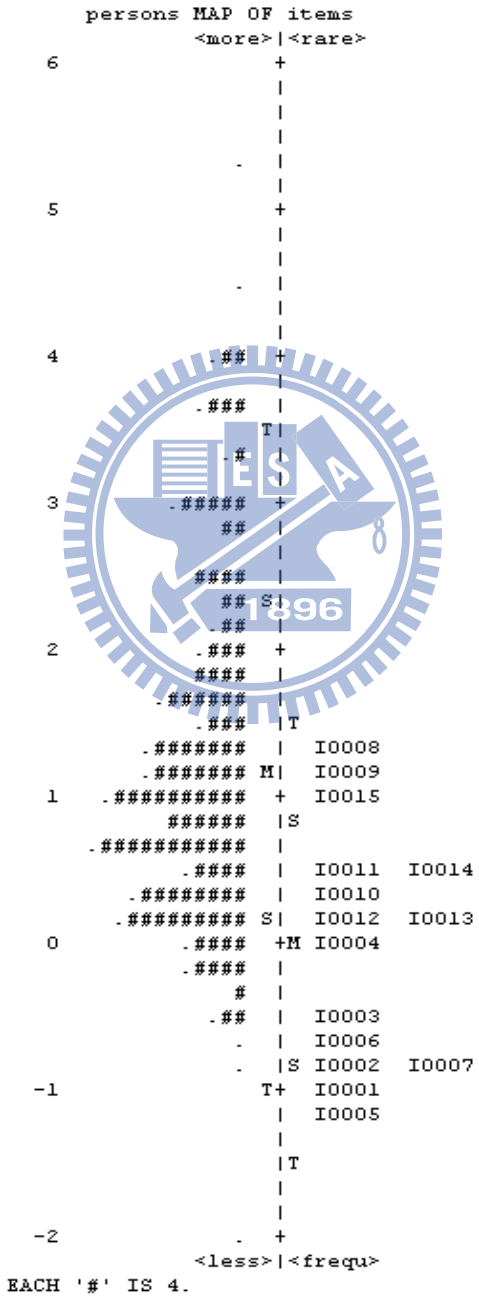
The Rasch model was also used to assess the self-rated policy beliefs of the 487 participants, the estimates of which ranged from 2.00 to 5.33 logits. Because the item and person parameters are both measured on the same interval-scaled unit (logit), the difference between the item and person estimates has a consistent meaning. The item–

person map as shown Figure 5.1 depicts the values of all parameters together and, therefore, provides a straightforward and graphical illustration of the relevant information behind the cross-comparisons of person and item parameters.

Similar to the figure used to demonstrate results in the previous study, the left field of the item–person map shows the distribution of the respondents' self-rated policy beliefs. The levels of beliefs are arranged from top to bottom. The number of respondents located at each level is represented by a combination of the symbols "#" and "." Respondents located higher on the map have levels of sustainable transport policy beliefs that are relatively high. The right field of the map shows the item estimates, which represent inherent resistance to beliefs in a sustainable transport development policy. When an item is located higher on the vertical axis, it is considered to be a tougher strategy for the public to support as a sustainable transport development policy. All item parameters are anchored at zero logit to provide a basis for comparisons. When the person and item parameters are located at the same level on the item–person map, there is a probability of 0.5 that he/she will consider the strategy as beneficial to implement sustainable transport development. If most respondents' beliefs (person parameters) are located at positions higher than the estimate of the corresponding strategies (item parameters), the strategies are considered to be relatively practicable.

According to the estimates shown on the item–person map (Figure 5.1), Item 8 (increasing gasoline prices) is considered as the least helpful strategy to implement, but 46% of the responding people felt confident that it would be an effective strategy to achieve the goal of sustainable transportation development. However, more than 90% of the respondents thought that the eight strategies with negative item estimates (i.e., Items 1, 2, 3, 4, 5, 6 and 7) would be helpful to achieve sustainable

transportation development, and more than 99% of the public supported the idea that implementing *the development of new energy sources* would achieve sustainable transportation development. Thus, the proportion of the public who are confident in a specific strategy to achieve sustainable transport development can be easily identified by examining the item–person map from the Rasch analysis.



Note “M”: mean measure. “S”: one-sample standard deviation. “T”: two-sample standard deviation.

Figure 5.1 Item–person map for responding the public.

Data regarding respondents' commuting modes were also collected by this survey. The commuting modes were divided into two groups. The first group of public transport includes walking, biking, bus, car pool, company bus, MRT, railway, and high-speed rail. The second group of private transport includes motorcycle, passenger car, and riding with family or friends. The Rasch analysis was applied to the two groups and results are shown in Tables 5.4 and 5.5, respectively.

The interpretation of the item sorting results in Table 5.4 is exactly the same as that for Table 5.3. It implies the ranking of policy preferences from the public transport commuters are the same as those from the all respondents.

In comparing Table 5.4 and Table 5.3, the resulted rankings are about the same. In terms of relative ranking, the only change is the swapping of positions between Item 1 and Item 5 as well as Item 12 and Item 13. In other words, the respondents who use private modes to commute believe that *constructing rail transport systems* is more effective than *developing new energy sources*, and were also under the impression that the effectiveness of *total vehicle volume control by limiting authorization of licenses* would be better than *implementing electronic toll collection (ETC)* for achieving sustainable transportation. The reason is that the private mode commuters are more comfortable with higher levels of personal energy use. As such, they associated themselves with the idea of developing new energy as being beneficial to facilitate sustainable transportation. However, they also think constructing a rail transportation system can advance sustainable transportation. Similarly, the commuters who use private cars/motorcycles, indicated their belief that the policy strength of *total vehicle volume control by limiting authorization of licenses* would be more effective than *implementing electronic toll collection (ETC).*

Table 5.4 Estimates of item measures and fit statistics from Rasch analysis for the respondents commuting by public transport

	Item	Estimate (b_i)	Infit Zstd		Outfit Zstd	
			MNSQ	Zstd	MNSQ	Zstd
5	Develop new energy sources (electrical cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	-1.14	1.05	0.5	1.06	0.6
1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	-0.90	0.86	-1.3	0.89	-1.0
2	Build public transport centers to facilitate transfer between different public transportation modes	-0.85	0.88	-1.1	0.94	-0.6
7	Build a friendly walking environment to reduce the use of private modes	-0.79	0.85	-1.4	0.83	-1.7
6	Establish bicycle lanes to promote the use of bicycle	-0.65	0.98	-0.2	1.04	0.4
3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	-0.44	0.99	-0.1	0.95	-0.4
4	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	-0.20	1.14	1.3	1.17	1.7
12	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emission	0.03	1.05	0.6	1.21	2.0
13	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	0.27	1.00	0.0	1.04	0.5
10	Encourage public and private firms to use public transport to slow the use of cars and motorcycles	0.28	0.94	-0.6	1.00	0.1
14	Ramp metering and HOV lane for freeways	0.34	0.89	-1.3	0.99	-0.1
11	Subsidize public to modify car by using LPG	0.39	0.99	-0.1	1.01	0.1
15	Congestion Road Pricing on CBD	1.06	1.02	0.3	1.03	0.4
9	Increase parking fees to reduce car use	1.20	0.93	-0.8	0.89	-1.3
8	Increase gasoline prices to reduce car use	1.41	0.80	-2.7	0.77	-3.0
	15 MEASURED items	Item Reliability: 0.99				
	269 MEASURED persons	Person Reliability: 0.84				

In contrast with data related to policy difficulties, private transport commuters, as opposed to public transport commuters, indicated that *constructing rail transport systems* would be the best policy for achieving sustainable transportation.

Table 5.5 Estimates of item measures and fit statistics from Rasch analysis for the respondents commuting by private transport

	Item	Estimate (b_i)	Infit Zstd		Outfit Zstd	
			MNSQ	Zstd	MNSQ	Zstd
1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	-1.19	0.92	-0.6	0.96	-0.3
5	Develop new energy sources (electrical cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	-1.06	0.93	-0.5	0.89	-0.9
2	Build public transport centers to facilitate transfer between different public transportation modes	-0.87	1.03	0.3	0.98	-0.1
7	Build a friendly walking environment to reduce the use of private modes	-0.83	0.90	-0.8	0.85	-1.2
6	Establish bicycle lanes to promote the use of bicycle	-0.79	0.86	-1.2	0.82	-1.5
3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	-0.60	0.79	-1.8	0.73	-2.6
4	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	0.19	1.05	0.5	1.10	0.9
13	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	0.21	1.11	1.1	1.09	0.8
12	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emission	0.26	1.15	1.4	1.19	1.7
10	Encourage public and private firms to use public transport to slow the use of cars and motorcycles	0.43	0.92	-0.8	1.00	0.0
14	Ramp metering and HOV lane for freeways	0.56	0.84	-1.7	0.90	-1.1
11	Subsidize public to modify car by using LPG	0.68	1.16	1.6	1.33	3.1
15	Congestion Road Pricing on CBD	0.88	1.13	1.4	1.24	2.4
9	Increase parking fees to reduce car use	0.94	1.04	0.4	1.06	0.7
8	Increase gasoline prices to reduce car use	1.20	1.06	0.6	1.06	0.7
	15 MEASURED items	Item Reliability: 0.98				
	218 MEASURED persons	Person Reliability: 0.85				

It is important to note the b_i index for *providing instant traffic information* is positive for private transport commuters, but negative for public transport commuters. This means that most private transport commuters believe that *providing instant*

traffic information is relatively ineffective for enhancing sustainable transportation. The reason might be that most private transport commuters have relatively fixed commuting time and routes, so it is not very important for them to receive instant traffic information. On the other hand, people who commute using public transport would need updated information regarding bus or train schedules. Therefore, they think that instant traffic information is beneficial for public transport for commuting, as well as achieving the goal of sustainable transport.

To further explore respondents' beliefs about which strategies can mitigate their private car/motorcycle use when traveling to work or school, we selected a subsample of those who answered "Strongly Agree" or "Agree" and then conducted a further Rasch analysis. The results are presented in Table 5.6.

As Table 5.6 (which should be compared with Table 5.3) demonstrates, the resulting rankings are approximately the same as the ones in Table 5.3. The difference is the reversal of rankings between Item 1 and Item 5. What this result suggests is that respondents who are willing to take action to reduce the usage of private transportation are more confident that *constructing rail transportation systems* would be beneficial to facilitate sustainable transportation than the full public sample.

Table 5.6 Estimates of item measures and fit statistics from Rasch analysis for the respondents willing to take action to reduce the use of private transportation

	Item	Estimate (b_i)	Infit Zstd		Outfit Zstd	
			MNSQ	Zstd	MNSQ	Zstd
1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	-1.08	0.90	-1.1	0.91	-1.0
5	Develop new energy sources (electrical cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	-1.06	1.00	0.0	0.99	-.1
2	Build public transport centers to facilitate transfer between different public transportation modes	-0.85	1.00	0.0	1.02	0.3
7	Build a friendly walking environment to reduce the use of private modes	-0.85	0.82	-2.0	0.80	-2.3
6	Establish bicycle lanes to promote the use of bicycle	-0.72	0.91	-0.9	0.94	-0.7
3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	-0.56	0.93	-0.7	0.88	-1.3
4	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	0.01	1.08	1.0	1.11	1.2
12	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emission	0.13	1.11	1.3	1.18	2.0
13	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	0.23	1.10	1.2	1.10	1.2
10	Encourage public and private firms to use public transport to slow the use of cars and motorcycles	0.45	0.85	-1.9	0.93	-0.9
14	Ramp metering and HOV lane for freeways	0.52	0.91	-1.2	0.95	-0.6
11	Subsidize public to modify car by using LPG	0.64	1.02	0.2	1.16	2.1
15	Congestion Road Pricing on CBD	0.89	1.13	1.8	1.21	2.7
9	Increase parking fees to reduce car use	1.00	1.05	0.7	1.03	0.5
8	Increase gasoline prices to reduce car use	1.26	0.96	-0.5	0.95	-0.6
	15 MEASURED items	Item Reliability: 0.98				
	357 MEASURED persons	Person Reliability: 0.83				

The MRT system has many positive characteristics (e.g., high capacity, high speed, short headway, punctuality, fewer accidents, low levels of pollution, and energy efficiency), which may be reasons why people who would like to mitigate the use of private transport would be attracted to using public transport to commute. Furthermore, people who would like to act to mitigate the use of private transport believe the economic instruments for raising usage costs of private transport (Items 8, 9, & 15) are more effective than the full public sample ("b_i" (the former ones) < "b_i" (the latter ones)). The results also reveal that those who are willing to act to mitigate private transport by using the economic instruments have stronger policy beliefs about achieving the target of sustainable transport, as compared to all respondents.

5.3.3 Differential Item Functioning (DIF) Analysis

Evaluating the degree to which measure meaningfulness is generalized across subgroups within a population is important. Studies that focus on validity at the item level within an instrument are investigating differential item functioning (DIF) (Myers, Wolfe, Feltz, & Penfield, 2006). Notably, DIF exists when an item functions varies with respondents from different groups.

Table 5.7 presents the DIF results for private and public transport commuters. The DIF measure columns represent each item's difficulty logits separately for those using public and private transportation. The DIF contrast column represents the difference between the DIF measures. A *t*-test was applied to examine differences between the measures of the two groups. The *p*-values indicate that policy beliefs associated with the items differ significantly between the two groups when marked with an asterisk (*) if $p < 0.05$. In this case, the DIF contrasts of Items 4, 11, and 12 are negative, which indicates these items cause more difficulties for people

commuting by public transport than private transportation. In other words, people who commuted by private transport are more confident than those using public transport commuters that *providing instant traffic information to reduce driving time*, *subsidizing the public to modify cars to use LPG*, and *implementing electronic toll collection (ETC)* would be effective approaches for achieving sustainable transportation,. In addition, the positive DIF contrast values for Items 8, 9, and 15 imply more difficulties for people who commuted using private transport than those using public transport. That is, people who commuted using public transport are more confident than private transport commuters that *congestion road pricing on CBD*, *increasing gasoline prices to reduce car use*, and *increasing parking fees to reduce car use* are better approaches to achieving sustainable transportation.

Table 5.7 The differences between various commute modes for each item and measuring policy beliefs (sorted by the DIF contrast)

Item		DIF Measure		DIF Contrast Pub.– Pri.	Prob.
		Public	Private		
4	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	-0.21	0.19	-0.40	0.0015*
11	Subsidize the public to modify cars by using LPG	0.34	0.66	-0.32	0.0052*
12	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emissions	0.02	0.26	-0.24	0.0490*
5	Develop new energy sources (electrical cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	-1.17	-1.02	-0.16	0.3309
14	Ramp metering and HOV lane for freeways	0.39	0.54	-0.16	0.1673
10	Encourage public and private firms to use public transport to slow the use of cars and motorcycles	0.28	0.42	-0.14	0.2328
2	Build public transport centers to facilitate transfer between different public transportation modes	-0.88	-0.83	-0.05	0.7513
7	Build a friendly walking environment to reduce the use of private modes	-0.82	-0.79	-0.03	0.8383
13	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	0.26	0.21	0.05	0.6746
6	Establish bicycle lanes to promote the use of bicycles	-0.67	-0.75	0.08	0.6003
3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	-0.46	-0.57	0.11	0.4589
1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	-0.93	-1.14	0.21	0.1931
15	Congestion Road Pricing on CBD	1.08	0.85	0.23	0.0283*
8	Increase gasoline prices to reduce car use	1.44	1.14	0.29	0.0053*
9	Increase parking fees to reduce car use	1.23	0.90	0.33	0.0021*

*$p < 0.05$

Table 5.8 presents the DIF results for people who owned or did not own a passenger car. Again, the *p*-values reveal whether policy beliefs associated with the items differed significantly between the two groups (i.e., * = $p < 0.05$). If the DIF measures of the two groups are both negative, it indicates the respondents of both groups generally have weak beliefs that the policy will result in sustainable

transportation, and both consider them to be difficult policies. Therefore, the items the not lend themselves to discussion in spite of the fact the DIF contrasts are significantly different. The results of the analysis examining subgroups that used private versus public transportation were the same as for those in subgroups that owned or did not own a passenger car.

Table 5.8 Differences between owning passenger car or not in terms of each item for measuring policy beliefs (ordered by DIF contrast)

Item		DIF Measure		DIF Contrast Own-Not	Prob.
		Own	Not		
1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	-1.39	-0.94	-0.44	0.0415*
15	Congestion Road Pricing on CBD	0.69	1.04	-0.35	0.0141*
9	Increase parking fees to reduce car use	0.81	1.15	-0.34	0.0153*
8	Increase gasoline prices to reduce car use	1.06	1.36	-0.31	0.0243*
3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	-0.60	-0.49	-0.11	0.5549
13	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	0.19	0.26	-0.06	0.6868
2	Build public transport centers to facilitate transfer between different public transportation modes	-0.88	-0.86	-0.02	0.9173
14	Ramp metering and HOV lane for freeways	0.47	0.45	0.02	0.8669
5	Develop new energy sources (electrical cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	-1.08	-1.11	0.03	0.8835
7	Build a friendly walking environment to reduce the use of private modes	-0.69	-0.83	0.15	0.4436
10	Encourage public and private firms to use public transport to slow the use of cars and motorcycles	0.54	0.29	0.25	0.0822
12	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emission	0.36	0.06	0.30	0.0466*
4	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	0.23	-0.10	0.33	0.0344*
11	Subsidize public to modify car by using LPG	0.74	0.42	0.33	0.0219*
6	Establish bicycle lanes to promote the use of bicycle	-0.40	-0.77	0.37	0.0431*

*$p<0.05$

5.4 Discussion

From this study, it was found that the public are more inclined to support the idea

of providing a more efficient and friendly public transportation service to attract their patronage than limiting private car use by increasing usage costs. In other words, they are more likely to support strategies that do not infringe on their preferences and freedoms. More specifically, people enjoy the freedom and flexibility their cars provide, and they would not want to be forced to change their transportation mode simply because of the increased costs of car use. Thus, people would support strategies that provide the options for people to make a choice to use public transportation or develop new energy sources (electric cars, fuel-batteries, etc.) to substitute for fossil fuel rather than strategies forcing people to use public transportation.

Developing new energy sources to substitute for fossil fuel can benefit public transportation from energy intensity improvement, but it takes a long time and can be difficult and expensive. Huby and Burkitt (2000) show that improving public transportation alone is not likely to make a significant impact on car use and should not be the only means to solve sustainable transportation problems. Therefore, developing an economic means (such as increasing usage costs) to limit private car use is indispensable to sustainable transportation in the short-term. Even if people have lower confidence in strategies related to increasing gasoline prices or parking fees, it does not mean those cost-increasing strategies are not worth pursuing. Policies to achieve sustainable transportation should be guided by strategies that alternatively use rewards and penalties. Through this approach, people can quickly learn which behaviors are and are not encouraged.

Respondents' commuting modes were also collected by this survey. The result shows that the policy preference rankings of the public transport commuters are the same as those using private transport modes. In terms of policy difficulties, private

transport commuters indicated that *constructing rail transport systems* is the best policy for achieving sustainable transportation. It seems reasonable to conclude that private transport commuters were more comfortable with higher personal energy use. The private transport commuters agreed with the idea that developing new energy sources is beneficial to facilitating sustainable transportation; however, slow action cannot save a critical situation; they also think *constructing rail transportation systems* will advance sustainable transportation.

It is important to note that the *bi* associated with *providing instant traffic information* for private transport commuters was positive, but negative for public transport commuters. That means most private transport commuters believe *providing instant traffic information* is relatively useless for enhancing sustainable transportation.

On the other hand, respondents willing to act to reduce private transport usage, as compared to all respondents, were more confident that the idea of *constructing rail transportation systems* would be of more benefit to facilitate sustainable transportation. People who would like to mitigate the use of their private transport would be attracted to using public transport to commute. The analysis also revealed that the policy beliefs of people willing to act to mitigate private transport using the economic instruments were stronger than all respondents' in achieving the goal of sustainable transport.

DIF is the resulting condition when an item functions differently for respondents from different groups. In this study, people who commuted by private transport were more confident than public transport commuters that *providing instant traffic information to reduce driving time, subsidizing the public to modify cars to use LPG,*

and *implementing electronic toll collection (ETC)* would achieve the goal of sustainable transportation. In addition, people who commute by public transport were more confident than private transport commuters that *congestion road pricing on CBD*, *increasing gasoline prices to reduce car use*, and *increasing parking fees to reduce car* would be better approaches for achieving sustainable transportation. The findings for subgroups of people who owned or did not own a passenger car were the same as for the subgroups using private or public transport.

CHAPTER 6 ANALYSIS OF THE BELIEFS IN SUSTAINABLE TRANSPORTATION POLICIES FROM SENIOR OFFICIALS AND THE PUBLIC

In this work, policy beliefs regarding sustainable transportation from the senior officials and the public were investigated and the conclusions are provided in previous chapters. It should be noted that the differences in the two questionnaires included the dates of the survey, policy items, and policy beliefs in the contributions of sustainable transportation policies. However, in order to explore differences in policy beliefs between the senior officials and the public, this chapter analyzes the differences between the two groups (the public vs. senior officials) and provides some noteworthy outcomes.

6.1 Samples Summing Analysis and Findings

The 12 common survey items for the senior officials and the public are shown in Table 6.1, and the results of the Rasch analysis are presented on Table 6.2. To test for uni-dimensionality, analytical results show that the first factor explains roughly 33.5% of variance and meets the criterion of 20% (Reckase, 1979). As before, the average of all item parameters was fixed at zero logit as a common reference for the relative interval scale, and the average of the policy beliefs across all respondents was 1.05 logit. The result indicates the respondents generally had strong beliefs in sustainable transportation policies.

Table 6.1 Common items with significance for the senior officials and the public

Items to explore self-rated perception		Type
Item 1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	5-point scale
Item 2	Build public transport centers to facilitate transfer between different public transportation modes	5-point scale
Item 3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	5-point scale
Item 4	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	5-point scale
Item 5	Develop new energy sources (electric cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	5-point scale
Item 6	Establish bicycle lanes to promote the use of bicycles	5-point scale
Item 7	Build a friendly walking environment to reduce the use of private modes	5-point scale
Item 8	Increase gasoline prices to reduce car use	5-point scale
Item 9	Increase parking fees to reduce car use	5-point scale
Item 10	Encourage public and private firms to use public transport to slow the use of cars and motorcycles	5-point scale
Item 11	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emissions	5-point scale
Item 12	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	5-point scale

The item reliability and person reliability are 0.99 and 0.83, respectively. Analytical results show that both the item separation index (13.7) and person separation (2.21) exceed 2, which indicates the items are sufficiently spread out to define distinct levels of policy beliefs measured in logits (Duncan et al., 2003).

Table 6.2 Model estimation and fit statistics obtained from Rasch analysis for both the senior officials and the public [a]

Items 12 Input 12 Measured						
	Raw score	No. of observations	Measure	SE	Infit Zstd	Outfit Zstd
Mean	2373.7	629	0.0	0.09	0.0	-0.1
Item reliability: 0.99			Item separation index: 13.70			
Item infit MNSQ: 0.99			Item infit Zstd: 0.0			
Persons 629 Input 629 Measured						
	Raw score	No. of observations	Measure	SE	Infit Zstd	Outfit Zstd
Mean	45.3	12	1.05	0.41	-0.1	-0.1
Person reliability: 0.83			Person separation index: 2.21			
Person infit MNSQ: 1.01			Person infit Zstd: -0.1			

Standardized Residual Variance (in eigenvalue units)			
		Empirical (%)	Modeled (%)
Total variance in observations	33.5	100	100
Variance explained by measures	21.5	64.2	63.4
Unexplained variance (total)	12.0	35.8	36.6
Unexplained variance explained by 1st factor	3.0	9.0	
Unexplained variance explained by 2nd factor	1.5	4.6	

[a]SE, standard error; Infit, information-weighted fit; Outfit, outlier-sensitive fit; Zstd, *Z*-standardized fit statistic.

Estimates of the item parameters are presented in Table 6.3. All item estimates have an Infit MNSQs and Outfit MNSQs of 0.79~1.15 and Zstd fit statistics between ±2 (except for Item 7 “build a friendly walking environment” and Item 10 “Encourage public and private firms to use public transport”). For comparison purposes, we ordered the items in Table 6.3 by their estimated values.

Items 8 and 9 have the two highest values of 1.32 and 1.16 logit, respectively, and that applies to both the senior officials and the public. These values indicate that Items 8 and 9 have the highest inherent resistance and result in the lowest levels of confidence that those strategies can be used to achieve sustainable transportation policy. On the other hand, the item with the lowest estimates is Item 1 (bi = –1.04).

These results show that all respondents (both the senior officials and the public) believe that *constructing rail transport systems* would be the most effective strategy and are confident in its benefiting sustainable transport.

Items 2, 3, 5, 6, and 7 also have negative estimates. Those values indicate that promoting public transport strategies of building public transport centers (Item 2), *building a friendly walking environment* (Item 7), *establishing bicycle lanes* (Item6), *integrating schedules and tickets for public transportation* (Item 3), and *developing new energy sources* (Item 5) are accepted by all respondents with confidence. On the other hand, Items 8, 9, 10, 11, and 12 (i.e., those with positive estimates) indicate the senior officials' and public's lack of confidence in their usefulness.

It can be concluded from Table 6.3 that only three items (8, 9, & 12) with lower ranking were viewed as restrictive strategies to limit private car usage, while others were thought of as encouraging strategies to emphasize the supply of better transportation alternatives. The results also indicate that all respondents are disinclined to be restrictive of driving in order to implement sustainable transportation development.

The results from this study indicate, based on practice and experience, both the senior officials and the public believe implementing a more efficient and friendly public transportation service to attract patronage would be a better strategy than limiting private car use by increasing costs. Thus, to avoid infringing on personal preferences and individual freedoms of people, they will support strategies that provide the option for people to use public transportation, but will not support strategies that force people to use public transportation.

Table 6.3 Estimates of item measures and fit statistics from Rasch analysis for both the senior officials and the public (ordered by item parameters)[a]

	Item	Estimate (b_i)	Infit Zstd		Outfit Zstd	
			MNSQ	Zstd	MNSQ	Zstd
1	Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	-1.04	0.99	-0.1	0.98	-0.3
5	Develop new energy sources (electrical cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	-0.84	1.11	1.6	1.02	0.3
2	Build public transport centers to facilitate transfer between different public transportation modes	-0.79	0.98	-0.3	0.91	-1.2
7	Build a friendly walking environment to reduce the use of private transport modes	-0.54	0.85	-2.1	0.79	-3.1
6	Establish bicycle lanes to promote the use of bicycles	-0.44	0.93	-1.0	0.91	-1.4
3	Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	-0.42	1.02	0.3	0.93	-0.9
4	Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	0.30	0.97	-0.5	1.00	0.0
10	Encourage public and private firms to use public transport to slow the use of cars and motorcycles	0.36	0.98	-0.4	1.15	2.3
12	Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	0.45	1.07	1.2	1.11	1.8
11	Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emissions	0.48	1.00	0.1	1.05	0.8
9	Increase parking fees to reduce car use	1.16	1.04	0.8	1.04	0.8
8	Increase gasoline prices to reduce car use	1.32	1.00	0.0	1.01	0.2

6.2 Analysis of Samples from Senior Officials and General Public

Since the sample sizes of the senior officials and the public are different, independent samples *t*-tests were applied to the mean scores of the two groups for a given item. An independent samples *t*-test is a statistical technique for analyzing the means from two independent groups. When drawing independent samples, if we take two samples from the same population, then the means of the two samples may be identical. However, if the samples are taken from two different populations, then the means of the samples can be different. In this case, independent samples *t*-tests are used to draw conclusions about the means of two populations and to determine whether or not they are similar.

In hypothesis testing using independent samples *t*-tests, statistical decisions are made about whether or not the means of the two populations are identical. If the observed value of the independent samples *t*-test is greater than or equal to the critical value at a predetermined significance level, the null hypothesis is rejected, indicating the means of the two groups are significantly different. If the observed value of the independent samples *t*-test is less than the critical value, then the means of the two groups are not significantly different.

Table 6.4 summarizes the results of the independent samples *t*-tests. The first column contains a description of each item. The second and third columns show the mean scores for each item for the public and the senior officials, respectively. The fourth column shows the mean between-groups differences, and the fifth column provides the observed *t*-value.

Table 6.4 Group Statistics of Independent-Samples T test

Items	Public (n=487)	S.O. (n=147)	Mean difference	*t*-value
Construct rail transport systems (e.g., MRT, HSR, Train, etc.) to promote public transportation	4.33	4.33	0.001	0.022
Build public transport centers to facilitate transfer between different public transportation modes	4.28	4.10	0.179	2.575*
Integrate schedules and tickets for public transportation (e.g., EasyCard, One Day Pass, etc.) to make transfer easier	3.84	2.53	1.313	13.796**
Provide instant traffic information to reduce driving time and, thus, reduce oil consumption and improve air quality	3.93	2.80	1.132	12.124**
Develop new energy sources (electrical cars, fuel-batteries, etc.) to substitute for the use of fossil fuel	4.37	3.91	0.454	6.231**
Establish bicycle lanes to promote the use of bicycles	4.22	3.64	0.584	7.371**
Build a friendly walking environment to reduce the use of private modes	4.26	3.71	0.555	7.374**
Increase gasoline prices to reduce car use	3.02	2.37	0.651	5.713**
Increase parking fees to reduce car use	3.19	2.40	0.790	6.709**
Encourage public and private firms to use public transport to slow the use of cars and motorcycles	3.72	3.31	0.404	4.745**
Implement electronic toll collection (ETC) on highways to alleviate congestion and, thus, reduce emissions	4.15	3.85	0.295	3.748**
Total vehicle volume control by limiting authorization of licenses (set quotas) to reduce auto growth	3.77	2.88	0.895	8.505**

***$p < .001$, ** $p < .01$, *$p < .1$

Taking the policy of *building public transport centers* as an example, there was a significant difference in the scores for the public (Mean=4.28) and the senior officials (Mean=4.10); mean difference = 0.719, $t = 2.575$. The result indicates that the public has a significantly stronger belief that *building public transport centers* would be effective in achieving sustainable transportation than do the senior officials. Actually, except for *constructing rail transport systems*, the public is more optimistic about the policies benefitting sustainable transportation than are the senior officials. Although the senior officials are responsible for making policy, the process of policy making

(including policy formation, formulation, adoption, implementation, and evaluation (Anderson, 2010) needs to be communicated in order to have consensus with stakeholders. Consequently, given all of the steps in the process, it may cause the senior officials to become more conservative and less confident in these policies based on their experience. On the contrary, with regard to *constructing rail transport systems*, there is no significance difference between the public and the senior officials.

The observations above are also presented in Figure 6.1. The horizontal and vertical axes are the mean scores of the senior officials and the public, respectively. Only *constructing rail transport systems* falls on the 45-degree line. Because each point on the 45-degree line means the variable measured on the vertical axis equals the variable measured on the horizontal axis; thus, it shows that there is no significant difference between two groups for *constructing rail transport systems*. The other policies plotted on the diagram are all located above the 45-degree line, which indicates the senior officials are more conservative than the public regarding their view of policies that will benefit sustainable transportation.

Since person and item parameters are relative, the average values of item difficulty are anchored at zero and thereby provide a common reference for comparisons. A more in-depth investigation of the item-person maps shows that all item difficulties are relatively concentrated as compared with their corresponding distributions of person abilities for the public and the senior officials (See Figure 6.2).

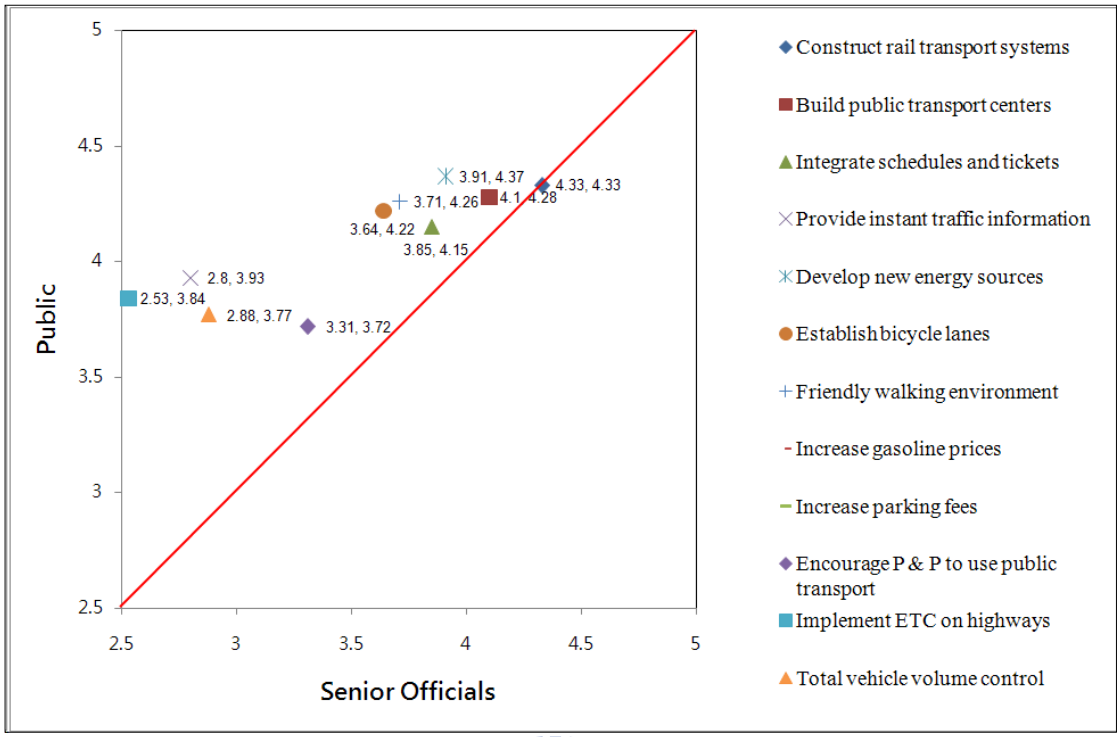


Figure 6.1 Distribution of mean scores of items for the public and the senior officials

According to the estimates shown on the item-person map (see the left portion of Figure 6.2), we can observe that Item 8 (Increasing gasoline prices to reduce car use) is perceived as being the most difficult strategy to implement. Only 16% of the responding senior officials felt they could achieve it with ease. In other words, only 16% of the responding senior officials felt confident that they could achieve this strategy for sustainable transport development. But for the public, 39.5% of the responding people felt confident that it would be an advantageous strategy to achieve the goal of sustainable transportation development.

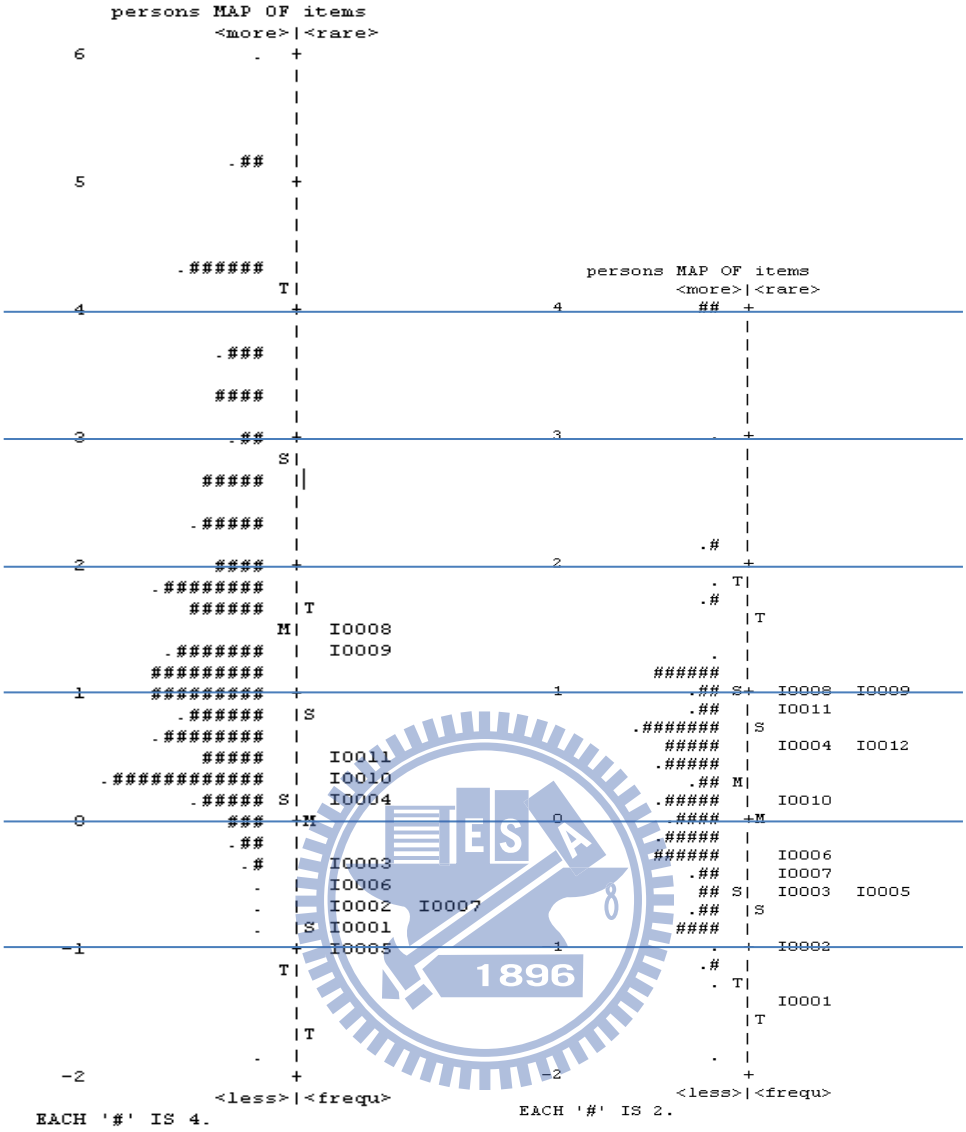


Figure 6.2 The item-person map of two groups by the same logit scale (the left side is the public, and the right side is the senior officials)

It is clear that 57.7 % of the respondent senior officials believed they could achieve sustainable transport policy by implementing the six strategies with negative item estimates (i.e., Items, 1, 2, 3, 5, 6, & 7). However, more than 95.9% of all respondents thought the same six strategies with negative item estimates (i.e., Items 1, 2, 3, 5, 6, & 7) could contribute to achieving sustainable transportation development.

CHAPTER 7 CONCLUSIONS AND FUTURE STUDY

7.1 Conclusions

The conclusions of this work can be summarized in three areas.

(1). The Senior Officials' Policy Beliefs

This study examined the nature of senior officials' policy beliefs and their levels of confidence in implementing various strategies for achieving sustainable transportation. We conceptualized the policy beliefs as a combined effect of a senior official's objective constraints and his/her subjective considerations. In addition, a policy belief can be viewed as a latent trait that is determined, in part, by levels of expertise, seniority or authority, and administrative experience. Senior officials are found to believe that providing a more efficient and friendly public transportation service to attract people's patronage would be more practicable than limiting private car usage by increasing costs. They are more likely to support strategies that do not infringe on personal preferences and freedoms. Thus, to avoid angering the public, officials would be more likely to support the strategies that can provide the option for people to make a choice to use public transportation rather than strategies forcing people to use public transportation.

A number of important implications were derived from this study regarding the future implementation of a sustainable transportation policy. First, as discussed above, the officials tend to neither displease the public nor support thankless strategies that infringe upon the rights of people. That is why they prefer the option of providing public transportation services to limiting private car use. They also agree that developing and promoting public transport can improve energy intensity. However, such an approach will take a long time and it is both difficult and expensive. In other

words, public transport should be given more priority, but it should not be the only means to solve transport problems in sustainable transportation.

Second, because constructing public transport cannot be completed in a short timeframe, developing economic approaches to limiting private car use (such as increasing usage costs) is indispensable to sustainable transportation for a short-term period. Administrators can educate people about expected behaviors by properly using both rewards and punishment. Moreover, the senior officials who are responsible for setting policy should be more positive in evaluating the costs and benefits of alternative strategies. If the senior officials cannot understand the necessity of economic instruments to reduce traffic, they need to be reeducated.

(2). The Public's Policy Beliefs

This study quantitatively evaluated policy beliefs regarding sustainable transportation from the general public using Rasch model. The results showed that not only senior officials but also the general public believe that providing a more efficient and friendly public transportation service to attract people's patronage would be more practicable than limiting private car use by increasing usage costs. Furthermore, the public believe that developing new energy sources (electric cars, fuel-batteries, etc.) to substitute for fossil fuel is the most helpful strategy, and they are confident that such an approach can benefit a sustainable transport environment.

Furthermore, an interesting lesson was learned by extending the results based on respondents' commuting modes. The policy preference rankings from public transport commuters were the same as from the general public. "Developing new energy sources" was found to be the strategy in which both the public and the private transport commuters were most confident for implementing sustainable transportation

policy. In addition, for the people who commuted by private transport but are willing to act to mitigate private transport use, their policy belief regarding *constructing rail transport systems* to achieve sustainable transport was stronger than the public as a whole.

After DIF analysis, significant differences in policy beliefs between the private and public transport commuters were revealed. Public transport commuters are more confident than private transport commuters in policies that would raise usage costs, such as “Congestion Road Pricing on CBD,” “Increase gasoline prices to reduce car use,” and “Increase parking fees to reduce car use.” In addition, to achieve the goal of sustainable transportation, people who commuted by private transport are more confident than public transport commuters in policies that “Provide instant traffic information to reduce driving time,” “Subsidize the public to modify cars to use LPG”, and “Implement electronic toll collection (ETC).” The findings and lessons learned from the two groups of people who owned and did not own a passenger car are the same as from the two groups using private or public transport.

(3). Comparison of Policy Beliefs Between Senior Officials and the Public

These results show that all respondents (senior officials and the public) believe that *constructing rail transport systems* is the most effective strategy and they are all confident that approach can benefit sustainable transport.

Furthermore, independent samples *t*-tests were applied to the mean scores of the senior officials and the public for each item. The result reveals the public believes more strongly than the senior officials that *building public transport centers* could be implemented to achieve sustainable transportation. Across all items, except for *constructing rail transport systems*, the public is more optimistic than the senior

officials that these policies will benefit sustainable transportation. In other words, the result indicates that the senior officials are more conservative than the public in terms of these policies benefitting sustainable transportation.

7.2 Recommendations for Future Study

(1). This study attempted to develop a tool for measuring the policy beliefs of senior officials and the general public on sustainable transportation policies. However, these two questionnaires were administered at different time and the policy items are not exactly the same across questionnaires. In addition, the sample sizes are different. Consequently, we could not compare the two groups using the same logit scale and, instead, we used mean scores to explore differences in policy beliefs between the senior officials and the public. Nonetheless, the questionnaires and experimental design can be further improved and tested. Future studies can continue to examine investigation methods for collecting qualified data.

(2). The conventional Rasch model is limited to exploring a single latent construct at a time under the assumption of uni-dimensionality. However, policies could be analyzed across many dimensions, such as pull and push strategies, using the multi-dimensional Rasch model, which recognizes the correlations and estimates parameters among the latent constructs (Wang, Chen, & Cheng, 2004). Such an instrument could be a communication platform for follow-up researchers.

(3). Rasch model analysis can facilitate the identification of effective policies that benefit a sustainable transportation environment. However, economic efficiency, measured by the difference between benefits and costs, should be the touchstone for making policy choices. Therefore, cost-benefit analysis of such policies can

be further explored in future research.

(4). In this study, we derived some meaningful conclusion from the respondents' information about their commuting modes and willingness to act to mitigate the usage of private transport. However, more demographic and socioeconomic factors can be collected in future surveys. As such, it would be helpful to conduct policies' market segmentation analysis.

7.3 Research Significance and Contributions

(1). Our concepts and approaches for measuring the level of a single latent trait can serve as a useful example for researchers who have to treat some latent traits as the influencing variables in statistical inference.

(2). The concept of individuals' policy beliefs in terms of both their socioeconomic and psychological natures was conceptualized in this study.

(3). Our exploration of policy beliefs can benefit researchers in modifying their formulations of policy preference, as well as the policy makers in enacting more effective policies.

REFERENCES

Anderson, J. E. (2010). *Public Policymaking: An Introduction, 7th edition*. California, US: Wadsworth Publishing

Andrich, D. (1978). A rating formulation for ordered response categories. *Psychometrika, 43*(4), 561-573.

Banister, D., & Button, K. (Eds.). (1993). *Transport, The environment and sustainable development*. London: Spon Press.

Black, J. S., Stern, P. C., & Elsworth, J. T. (1985). Personal and contextual influences on household energy adaptations. *Journal of Applied Psychology, 70*(1), 3-21.

Bond, T. G., & Fox, C. M. (2001). *Applying the Rasch model: Fundamental measurement in the human sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.

Cai, W., Wang, C., Chen, J., Wang, K., Zhang, Y., & Lu, X. (2008). Comparison of CO_2 emission scenarios and mitigation opportunities in China's five sectors in 2020. *Energy Policy, 36*(3), 1181-1194.

Chang H. L., & Chen, P. C. (2009). Exploring senior officials' policy beliefs regarding sustainable transportation. *Transportation Research Part D: Transport and Environment, 14*(4), 249-254.

Chang H. L., & Wu, S. C. (2008). Exploring the vehicle dependence behind mode choice: Evidence of motorcycle dependence in Taipei. *Transportation Research Part A: Policy and Practice, 42*(2), 307-320.

Collantes, G. (2008). The dimensions of the policy debate over transportation energy: The case of hydrogen in the United States. *Energy Policy, 36*(3), 1059-1073.

Duncan, P. W., Bode, R. K., Lai, S. M., Perera, S. & Antagonist, G. (2003). Rasch analysis of a new stroke-specific outcome scale: the stroke impact scale. *Archives of Physical Medicine and Rehabilitation, 84*(7), 950-963.

Dunlap, R. E., & Van Liere, K. D. (1978). The new environmental paradigm. *Journal of Environmental Education, 9*(4), 10–19.

EEA. (2002). *Environmental signals 2002* (Environmental Assessment Report No. 9). Copenhagen: European Environment Agency. Retrieved from

http://reports.eea.eu.int/environmental assessment report 2002 9/en.

Eriksson, L., Garvill, J., & Nordlund, A. M. (2006). Acceptability of travel demand management measures: The importance of problem awareness, personal norm, freedom, and fairness. *Journal of Environmental Psychology, 26*(1), 15–26.

European Commission. (2001). *White Paper on European transport policy up to 2010: Time to decide*. Brussels. Retrieved from http://europa.eu.int/comm/energy transport/en/lb en.html.

Feitelson, E. (2002). Introducing environmental equity dimensions into the sustainable transport discourse: Issues and pitfalls. *Transportation Research Part D: Transport and Environment, 7*(2), 99-118.

Fisher, W. P. Jr., Harvey, R. F., Taylor, P., Kilgore, K. M. & Kelly, C. K. (1995). Rehabits: Common language of functional assessment. *Archives of Physical Medicine and Rehabilitation, 76*(2), 113-122.

Greene, D. L., & Wegener, M. (1997). Sustainable transport. *Journal of Transport Geography, 5*(3), 177-190.

Guttman, L. (1950). The basis for scalogram analysis. In Stouffer *et al. Measurement and Prediction*. The American Soldier Vol. IV. New York: Wiley

Hambleton, R. K., Swaminathan, H., & Rogers, H. J. (1991). *Fundamentals of item response theory*. Newbury Park, CA: Sage Publications.

Harrison, C., & Burgess J. (2000). Valuing nature in context: The contribution of common-good approaches. *Biodiversity and Conservation 9*(8), 1115–1130.

Hopper, J. R., & Nielsen, J. M. (1991). Recycling as altruistic behavior: Normative and behavioral strategies to expand participation in a community recycling program. *Environment and Behavior, 23*(2), 195–220.

Hovardas, T., & Poirazidis, K. (2007). Environmental policy beliefs of stakeholders in protected area management. *Environment Manage, 39*(4), 515-525.

Huby M., & Burkitt N. (2000), Is the new deal for transport really better for everyone? The social policy implications of the UK 1998 White Paper on transport. *Environment and Planning C: Government and Policy, 18*(4), 379-392.

International Energy Agency. (2002). *World energy outlook 2002*. Paris, France: International Energy Agency.

Konidari, P., & Mavrakis, D. (2007). A multi-criteria evaluation method for climate change mitigation policy instruments. *Energy Policy, 35*(12), 6235-6257.

Linacre, J. M., & Wright B. D. (1997). *A user's guide to Winsteps: Rasch-Model computer program*. Chicago, IL: MESA Press.

Lubell, M., & Leach, W. D. (2005). Watershed partnerships: Evaluating a collaborative form of public participation. *Prepared for the National Research Council's Panel on Public Participation in Environmental Assessment and Decision Making.* Washington D.C.

Lund, F. (2007). *Changing social policy: The child support grant in South Africa*. Cape Town: Human Sciences Research Council Press.

Massof, R. W., & Fletcher, D. C. (2001). Evaluation of the NEI visual functioning questionnaire as an interval measure of visual ability in low vision. *Vision Research, 41*(3), 397-413.

Masters, G. N. (1982). A Rasch model for partial credit scoring. *Psychometrika, 47*(2), 149-174.

MOTC. (2006). *Assessment and Strategies Planning For Energy Saving and Greenhouse Gas Reduction Potential of Transportation Sector*. Taipei: IOT, MOTC.

MOTC, (2009). *The Study on the Planning of the Responding Strategies to the Post-Kyoto Period for the Transport Sector in Taiwan* Taipei: IOT, MOTC.

Myers, N. D., Wolfe, E. W., Feltz, D. L., & Penfield, R. D. (2006). Identifying differential item functioning of rating scale items with the Rasch model: An introduction and an application. *Measurement in Physical Education and Exercise Science, 10*(4), 215-240.

Nijkamp, P. (1994). Roads toward environmentally sustainable transport. *Transportation Research Part A: Policy and Practice, 28*(4), 261-271.

Nordlund, A. M., & Garvill, J. (2002). Value structures behind proenvironmental behavior. *Environment and Behavior, 34*(6), 740–756.

Nordlund, A. M., & Garvill, J. (2003). Effects of values, problem awareness, and personal norm on willingness to reduce personal car use. *Journal of Environmental Psychology, 23*(4), 339–347.

OECD. (2002). *Road travel demand: Meeting the challenge*. Paris, France: OECD Publishing.

Olsson, L. (1999). Steps towards an environmentally sustainable transport system. *The Science of the Total Environment, 235*(1-3), 407-409.

Parkhurst, G. (2004). Air quality and the environmental transport policy discourse in Oxford. *Transportation Research Part D: Transport and Environment, 9*(6), 419–436.

Poortinga, W., Steg, L. & Vlek, C. (2002). Environmental risk concern and preferences for energy-saving measures. *Environment and Behavior, 34*(4), 455–478.

Poortinga, W., Steg, L. & Vlek, C. (2004). Values, environmental concern, and environmental behavior: A study into household energy use. *Environment and Behavior, 36*(1), 70–93.

Rasch, G. (1960). *Probabilistic models for some intelligence and attainment tests.* Copenhagen: Danish Institute for Educational Research.

Reckase, M. D. (1979). Uni-factor latent trait models applied to multifactor tests: Results and implications. *Journal of Educational Statistics, 4*(3), 207-230.

Reeve, B. B., Hays, R. D., Bjorner, J. B., Cook, K. F., Crane, P. K., Teresi, J. A., Thissen, D., …Cella, D. (2007). Psychometric evaluation and calibration of health-related quality of life item banks: Plans for the patient-reported outcomes measurement information system (PROMIS). *Medical Care, 45*(5), S22-S31.

Rubio, V. J., Aguado, D., Hontangas, P. M. & Hernandez, J. M. (2007). Psychometric properties of an emotional adjustment measure: An application of the Graded Response Model. *European Journal of Psychological Assessment, 23*(1), 39-46.

Ryan, S., & Throgmorton, J. A. (2002). Sustainable transportation and land development on the periphery: A case study of Freiburg, Germany and Chula Vista, California. *Transportation Research Part D: Transport and Environment, 8*(1), 37-52.

Scherbaum, C. A., Finlinson, S., Barden, K. & Tamanini, K. (2006). Applications of

item response theory to measurement issues in leadership research. *The Leadership Quarterly, 17*(4), 366-386.

Schwartz, S. H. (1977). Normative influences on altruism. *Advances in Experimental Social Psychology, 10,* 221–279.

Shiftan, Y., Kaplan, S. & Hakkert, S. (2003). Scenario building as a tool for planning a sustainable transportation system. *Transportation Research Part D: Transport and Environment, 8*(5), 323-342.

Smith, R. M. (1991). The distributional properties of Rasch item fit statistics. *Educational and Psychological Measurement, 51*(3), 541-565.

Smith, R. M., Schumacker, R. E., & Bush, M. J. (1995). *Using item mean-squares to evaluate fit to the Rasch model*. Paper presented at the 1995 Annual Meeting of the American Educational Research Association in San Francisco.

Steg, L., & Vlek, C. (1997). The role of problem awareness in willingness- to-change car use and in evaluating relevant policy measures. In: J.A. Rothengatter & E. Carbonell Vaya (Eds.), *Traffic and Transport Psychology. Theory and Application* (pp. 465-475). Oxford: Pergamon.

Steg, L., Dreijerink, L. & Abrahamse, W. (2005). Factors influencing the acceptability of energy policies: A test of VBN theory. *Journal of Environmental Psychology, 25*(4), 415–425.

Stern, P. C. (2000). New environmental theories: Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues, 56*(3), 407–424.

Stern, P. C., Dietz, T. & Guagnano, G. A. (1995). The New Ecological Paradigm in social-psychological context. *Environment and Behavior, 27*(6), 723–743.

Stern, P. C., Dietz, T., Abel, T., Guagnano, G. A. & Kalof, L. (1999). A value-belief-norm theory of support for social movements: The case of environmentalism. *Human Ecology Review, 6*(2), 81–97.

Stoll-Kleemann, S. (2001). Barriers to nature conservation in Germany: A model explaining opposition to protected areas. *Journal of Environment Psychology, 21*(4), 369–385.

Streiner, D. L., & Norman, G. R. (2004). *Health measurement scales. A practical*

guide to their development and use (3rd ed.) New York: Oxford University Press.

Tarrant, M. A., & Cordell, H. K. (2002). Amenity values of public and private forests: Examining the value-attitude relationship. *Environment Management, 30*(5), 692-703.

Thompson, S. C., & Barton, M. A. (1994). Ecocentric and anthropocentric attitudes toward the environment. *Journal of Environmental Psychology, 14*(2), 149-157.

Torgerson, D. (1995). The uncertain quest for sustainability: Public discourse and the politics of environmentalism. In: Frank, F., Michael, B. (Eds.), *Greening Environmental Policy: The Politics of a Sustainable Future* (pp. 3-20). New York: St. Martin's Press.

Tuominen, A., & Himanen, V. (2007). Assessing the interaction between transport policy targets and policy implementation - A Finnish case study. *Transport Policy, 14*(5), 388–398.

Walton, W. & Farrington, J. (2000). The sustainable transport study for Aberdeen: A pioneering attempt at a 'multimodal study'. *Environment and Planning C: Government and Policy, 18*(5), 609-627.

Wang, W. C., Chen, P. H. & Cheng, Y.Y . (2004). Improving measurement precision of test batteries using multidimensional item response models. *Psychological Methods, 9*(1), 116-136.

WBCSD. (2001). *Mobility 2001*. World mobility at the end of the twentieth century and its sustainability. Geneva: World business council for sustainable development. Retrieved from http://www.wbcsdmobility.org/publications/mobility2001.asp.

Whitelegg, J. (1993). *Transport for a sustainable future: The case of Europe*. London: Belhaven Press.

Widegren, Ö. (1998). The New Environmental Paradigm and personal norms. *Environment and Behavior, 30*(1), 75-100.

World Bank. (1996). *Sustainable Transport: Priorities for Policy Reform*. Washington, DC: World Bank. Retrieved from

http://www.world-bank.org/transport/pol_econ/tsr.htm.

World Commission on Environment and Development. (1987). *Our common future*, Oxford, England: Oxford University Press.

Wright, B.D. (1977). Solving measurement problems with the Rasch model. *Journal of Educational Measurement, 14*(2), 97-116.

Wright, B. D. (1996). Reliability and separation. *Rasch Measurement Transactions, 9*(4), 472.

Wright, B. D. & Linacre, J. M. (1994). Reasonable mean-square fit values. *Rasch Measurement Transactions, 8*(3), 370.

Wright, B. D., & Masters, G. N.. (1982). *Rating scale analysis*. Chicago: MESA Press.

Wright, B. D., & Stone, M. H. (1979). *Best test design*. Chicago: MESA Press,

Zachariadis, T. (2005). Assessing policies towards sustainable transport in Europe: An integrated model, *Energy Policy, 33*(12), 1509-1525.

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(A) Journal Papers

Chang, H.L. & **Chen, P.C.** (2011). A Novel Approach for Assessing the Public's Policy Beliefs in Sustainable Transportation. *Journal of the Eastern Asia Society for Transportation Studies*. (Accepted for the Journal with conditions)

Chang, H.L. & **Chen, P.C.** (2009). Exploring senior officials' policy beliefs regarding sustainable transportation. *Transportation Research Part D: Transport and Environment, 14*(4), 249-254. (SCI, SSCI)

Chang, H.L. & **Chen, P.C.** (2005). The impact of traffic information on drivers' route choice - using competence sets analysis. *Journal of the Eastern Asia Society for Transportation Studies, 6*, 2425-2440.

(B) Conference Proceedings

張新立、**陳賓權**、林忠漢，(2011)。事前資訊品質對用路人路徑選擇行為之影響。海峽兩岸智慧交通學術研討會。

張新立、**陳賓權**、林忠漢，(2008)。具不確定性事前資訊提供下用路人理性預期路徑選擇行為之變化。中華民國運輸學會 2008 年年會暨學術論文國際研討會論文集，1083-1112 頁。

陳賓權、黃運貴、黃新薰，(2008)。推動溫室氣體減量法對運輸部門之衝擊及因應策略，中華民國運輸學會 97 年學術論文國際研討會。

陳賓權、黃運貴、黃新薰，(2007)。綠色運輸系統教育宣導網站規劃與建置維護」，中華民國運輸學會 96 年學術論文國際研討會。

陳賓權、黃運貴、黃新薰，(2006)。運輸部門能源節約及溫室氣體減量潛力評估與因應策略規劃，中華民國運輸學會 95 年學術論文國際研討會。

陳賓權、陳一昌、黃運貴，(2003)。環境影響評估審查案管理資訊系統，中華民國運輸學會 92 年學術論文國際研討會，民國 92 年 12 月。

(C) Reports:

陳賓權、黃運貴、黃新薰，(2008)。第 5 次 APEC 運輸部長雙邊會談議題暨我方立場擬議，運輸研究專輯，25 期。

陳賓權、黃運貴、黃新薰，(2008)。液化石油氣（LPG）車輛相關議題分析，運輸研究專輯，25 期。

陳賓權、黃運貴、黃新薰，(2008)。運輸部門「溫室氣體減量法草案」因應措施，運輸研究專輯，25 期。

陳賓權、黃運貴、黃新薰，(2007)。運輸部門在替代能源車輛研究發展與推廣扮演角色之探討，運輸研究專輯，22 期。

陳賓權、黃運貴、黃新薰，(2007)。鼓勵所屬員工上下班使用大眾運輸工具之

國內外相關措施，運輸研究專輯，21 期。

陳賓權、黃運貴、黃新薰，(2007)。國際無車日活動彙整與探討，運輸研究專輯，21 期。

陳賓權、黃運貴、黃新薰、蔣敏玲，(2007)。ITS 效益評估軟體(IDAS)介紹，運輸研究專輯，20 期。

陳賓權、黃運貴、黃新薰，(2007)。IDAS 實例分析-以高速公路匝道儀控系統為例，運輸研究專輯，20 期。

陳賓權、黃運貴、黃新薰、楊智凱，(2007)。「2005 全國能源會議」運輸部門行動方案，運輸研究專輯，17 期。

(D) Research Projects

陳賓權、黃運貴、黃新薰、江明穎，(2008)。綠色運輸系統發展政策之探討，交通部運輸研究所。

陳賓權、黃運貴、黃新薰、朱珮芸、楊智凱、張益城、蔣敏玲、林忠欽、江明穎，(2008)。因應後京都時期運輸部門發展策略規劃之研究，交通部運輸研究所。

倪佩貞、劉國棟、郭明哲、洪義順、楊玉妃、鍾慧諭、陳柏君、李宗益、莊沅融、費雅琴、**陳賓權**、黃新薰、黃運貴，(2008)。運輸部門能源與溫室氣體資料之構建與盤查機制之建立（2/3）-建立溫室氣體排放盤查、登錄、查驗標準與機制，交通部運輸研究所。

陳賓權、蔣敏玲、黃新薰，(2007)。ITS 效益評估分析軟體應用與實例分析，交通部運輸研究所。

陳奕廷、蔡秉錡、林聖偉、陳逸勳、張建彥、張婷瑋、張希洛、**陳賓權**、黃運貴、黃新薰、江明穎，(2007)。綠色運輸系統教育宣導網站規劃與建置維護（第二年期），交通部運輸研究所。

倪佩貞、洪義順、楊玉妃、陳柏君、李宗益、薛乃嘉、費雅琴、**陳賓權**、黃新薰、黃運貴，(2007)。運輸部門能源與溫室氣體資料之構建與盤查機制之建立（1/3）-探討運輸部門政策對溫室氣體排放量之影響，交通部運輸研究所。

陳奕廷、蕭再安、蔡秉錡、趙延祥、張希洛、林文雅、**陳賓權**、黃運貴、黃新薰，(2006)。綠色運輸系統教育宣導網站規劃與建置維護（第一年期），交通部運輸研究所。

陳奕廷、林宜達、趙延祥、顏智淵、邱鼎文、曹金湖、**陳賓權**、黃運貴、黃新薰，(2006)。建立交通衝擊評估空間資料庫及應用機制之研究，交通部運輸研究所。

林伯澄、許心萍、林貴璽、倪佩貞、曾勇誠、鄭欽宗、**陳賓權**、黃運貴、黃新薰，(2006)。智慧型運輸系統(ITS)對節約能源及減少溫室氣體排放之效益評估(2/2) ，交通部運輸研究所。

曾勇誠、林柏澄、林貴璽、江彥雄、鄭欽宗、楊金華、蔡瑞鉉、**陳賓權**、陳一昌、黃運貴，(2005)。智慧型運輸系統(ITS)對節約能源及減少溫室氣體排放之效益評估(1/2) ，交通部運輸研究所。

陳賓權、黃新薰、黃運貴，(2005)。探討資訊不確定性對駕駛行為之影響，交通部運輸研究所。

陳奕廷、林宜達、易志中、顏智淵、林耿同、陳美華、**陳賓權**、黃運貴、黃新薰，(2005)。環境影響評估地理資訊系統之建置，交通部運輸研究所。

陳一昌、黃運貴、**陳賓權**，(2005)。應用能力集於探討交通資訊對旅行者路徑選擇之影響，交通部運輸研究所。

倪佩貞、洪義順、龍贊良、陳柏君、李宗益、費雅琴、**陳賓權**、黃運貴、黃新薰，(2005)。運輸部門能源節約及溫室氣體減量潛力評估與因應策略規劃，交通部運輸研究所。

陳一昌、黃運貴、楊智凱、張芳旭、朱珮芸、**陳賓權**、張益城、蔣敏玲，(2004)。智慧型運輸系統 ITS 應用技術現況(2002~2003)及最新發展趨勢，交通部運輸研究所。

陳一昌、黃運貴、張芳旭、朱珮芸、**陳賓權**、楊智凱、張益城、蔣敏玲、曹瑞和、周家慶、趙志民、吳東凌、何毓芬、陳其華、蔡欽同、張仲杰、蘇振維、張瓊文，(2003)。台灣地區智慧型運輸系網要計畫-2003-2010，交通部運輸研究所。(獲行政院傑出研究獎優等獎)

陳一昌、**陳賓權**，(2003)。環境影響評估審查案管理資訊系統，交通部運輸研究所。